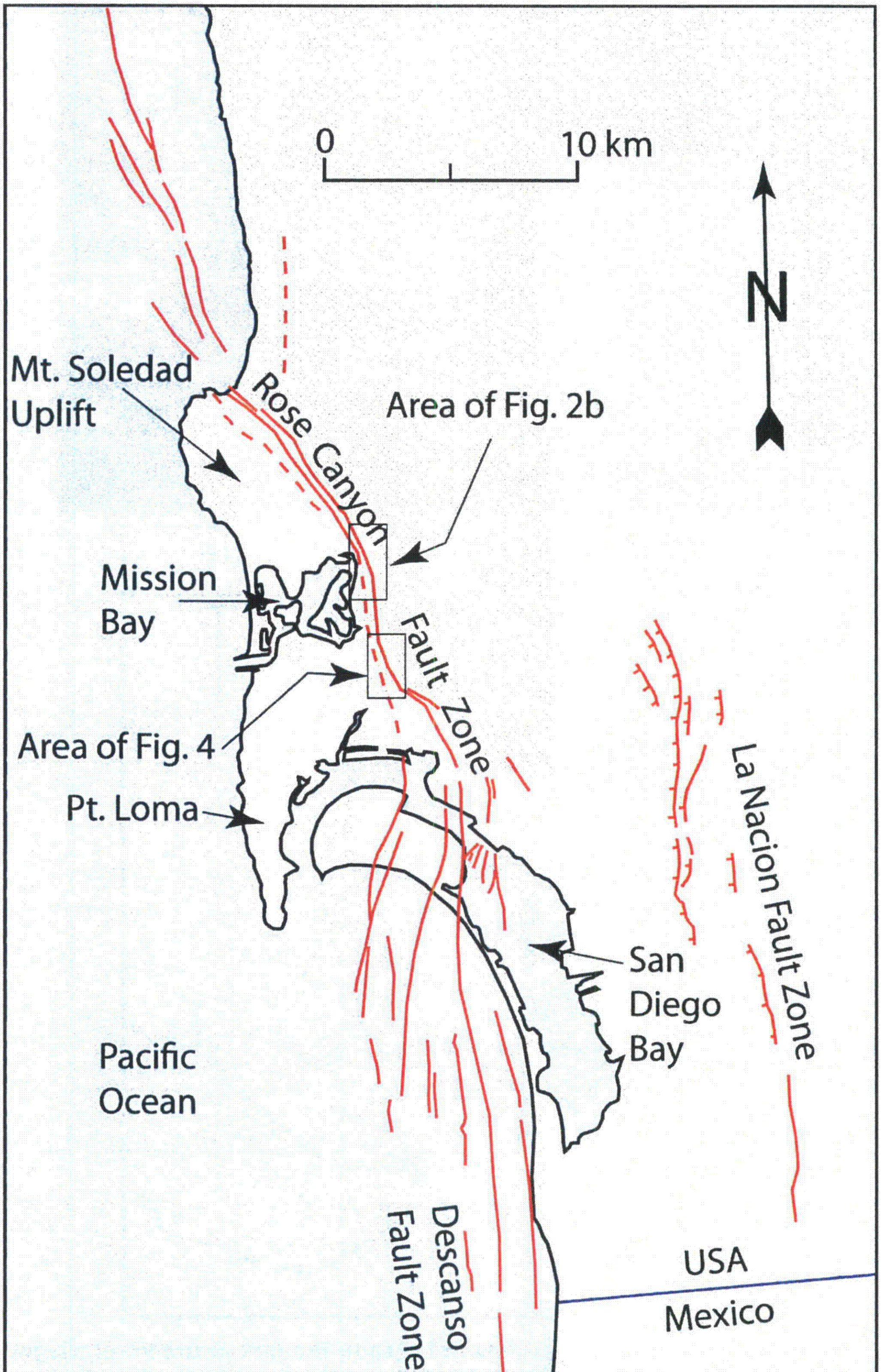


GeoPentech

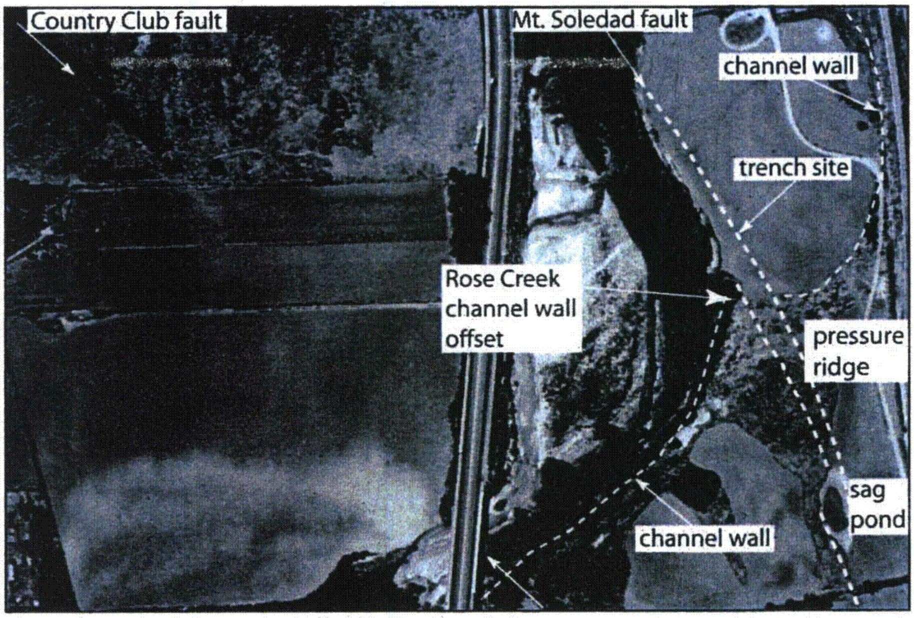
By Rockwell (2010)

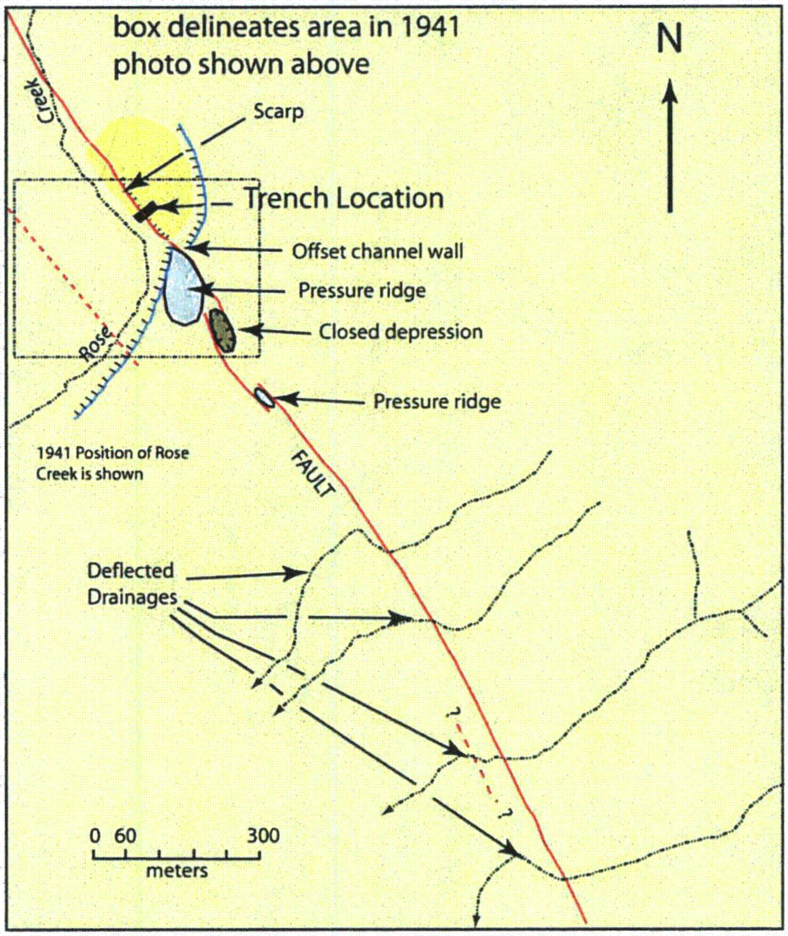
MAP OF THE MAIN ELEMENTS OF THE ROSE CANYON FAULT IN SAN DIEGO

FIGURE A2-1

SAN ONOFRE NUCLEAR GENERATING STATION

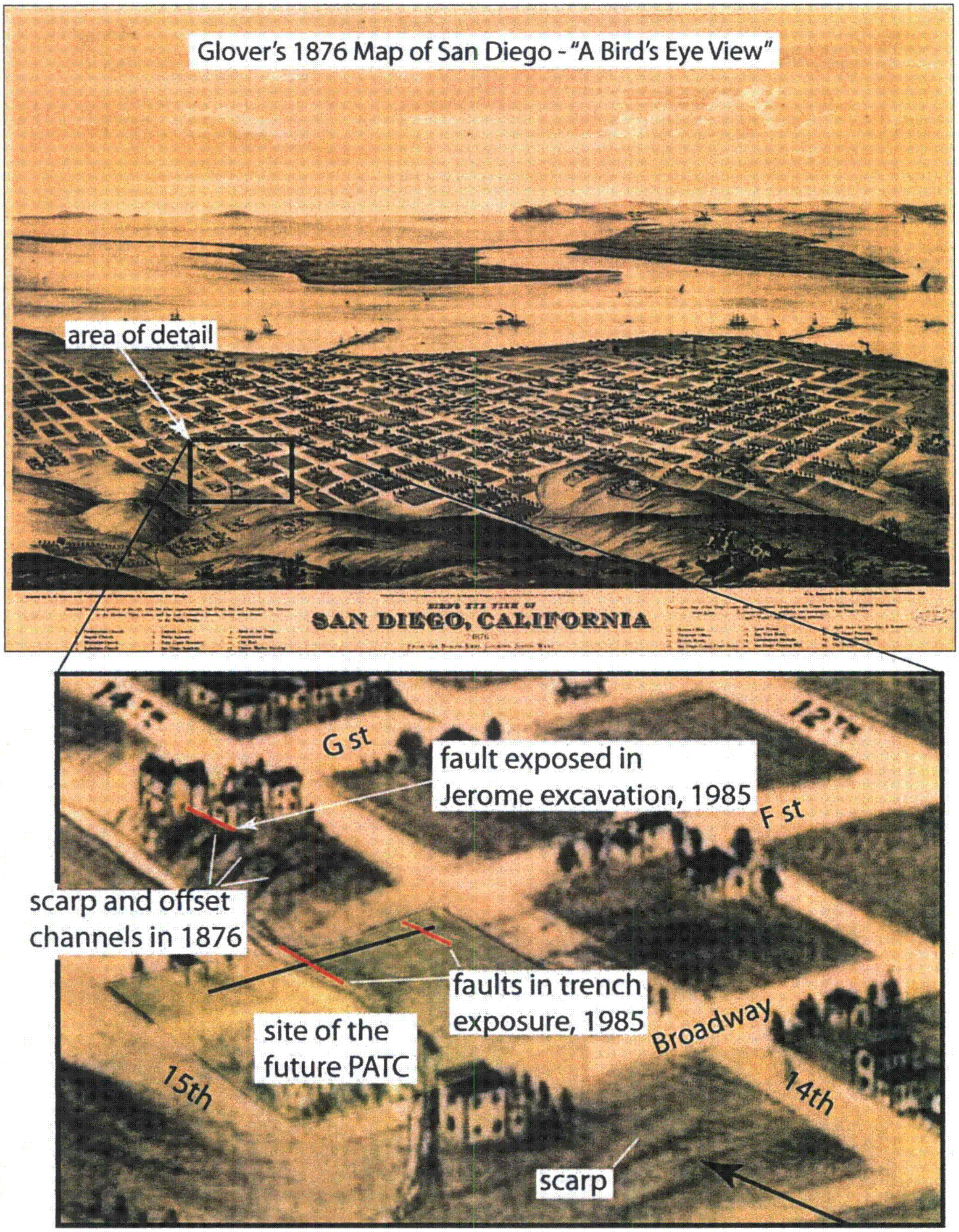
SEISMIC HAZARD ASSESSMENT PROGRAM





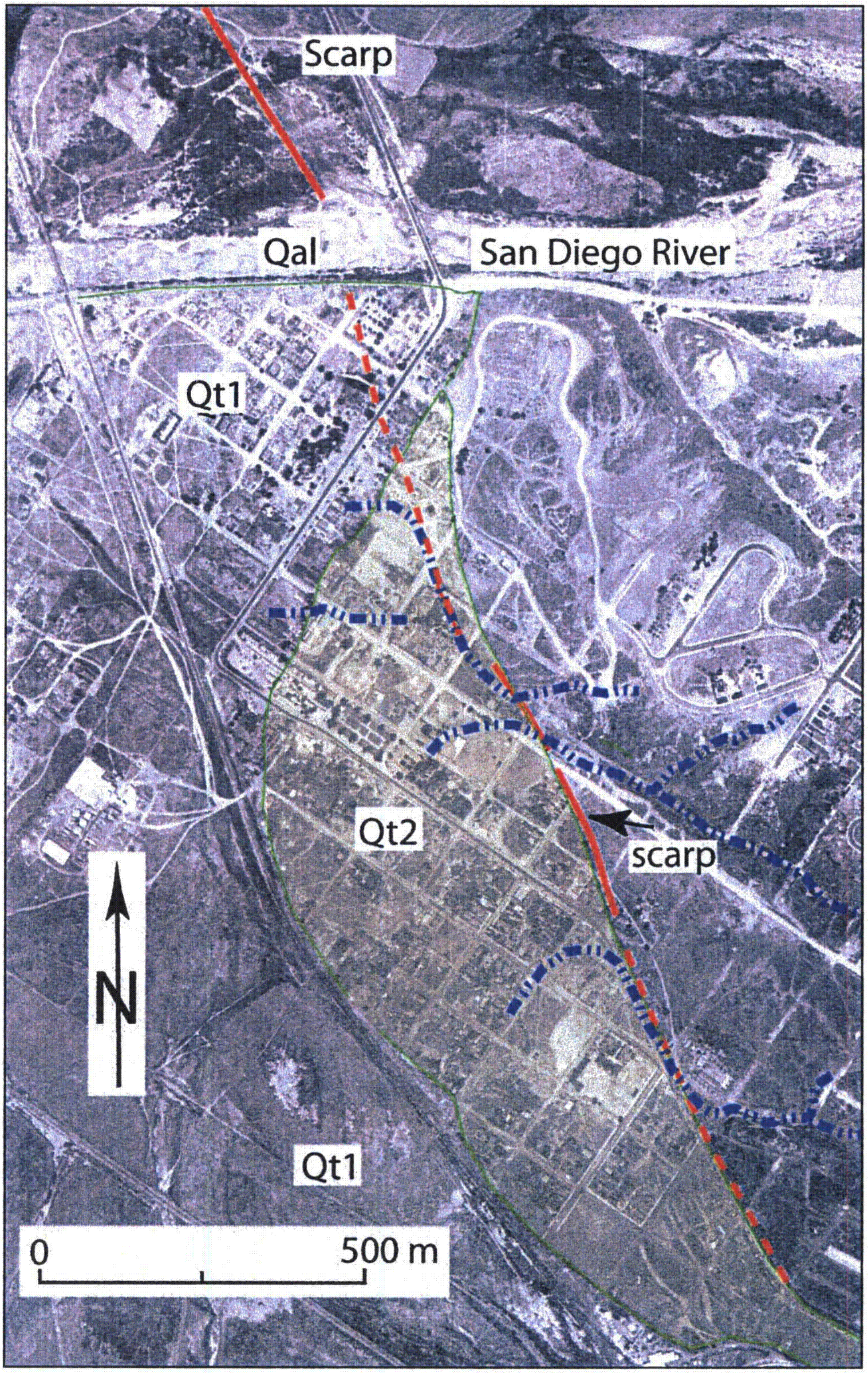
NOTE: Annotated air photo (upper) shows detail of area in the box in the lower diagram (from Lindvall and Rockwell, 1995, Rockwell, 2010).

GeoPentech Geotechnical & Geoscience Consultants	**INTERPRETIVE MAP OF TECTONIC GEOMORPHIC FEATURES IN THE ROSE CREEK AREA**	FIGURE A2-2
By Rockwell (2010)	**SAN ONOFRE NUCLEAR GENERATING STATION** SEISMIC HAZARD ASSESSMENT PROGRAM	



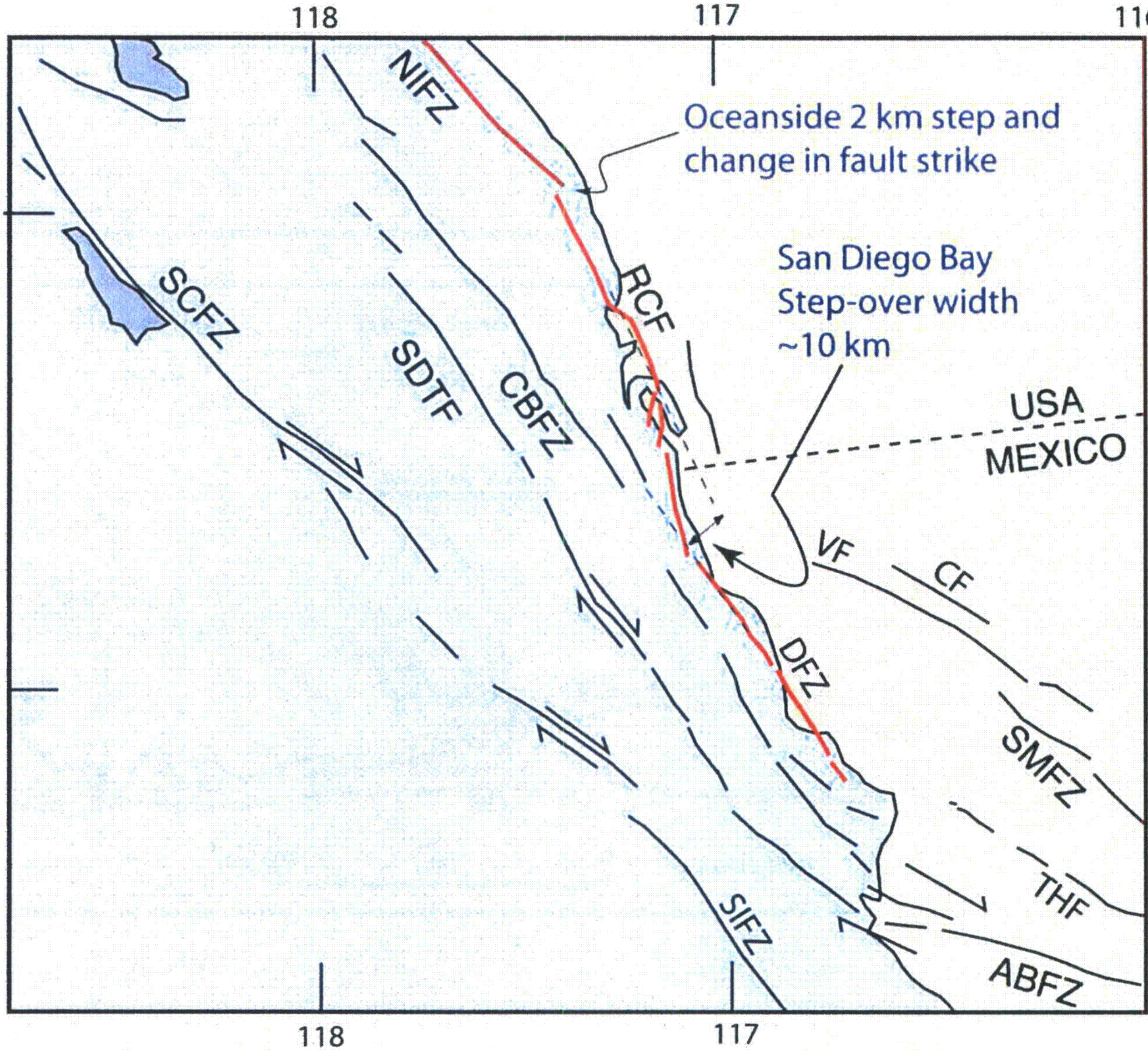
NOTE: Remarkably, the artist's eye picked out and drew scarps and deflected drainages along the Rose Canyon fault: the location of the fault in this area was determined by excavations in 1985 for the new Police headquarters building (PATC) and for a foundation excavation for a Jerome's warehouse.

GeoPentech Geotechnical & Geoscience Consultants	**ANNOTATED ARTIST'S RENDITION OF DOWNTOWN SAN DIEGO IN 1876**	FIGURE A2-3
By Rockwell (2010)	**SAN ONOFRE NUCLEAR GENERATING STATION** SEISMIC HAZARD ASSESSMENT PROGRAM	



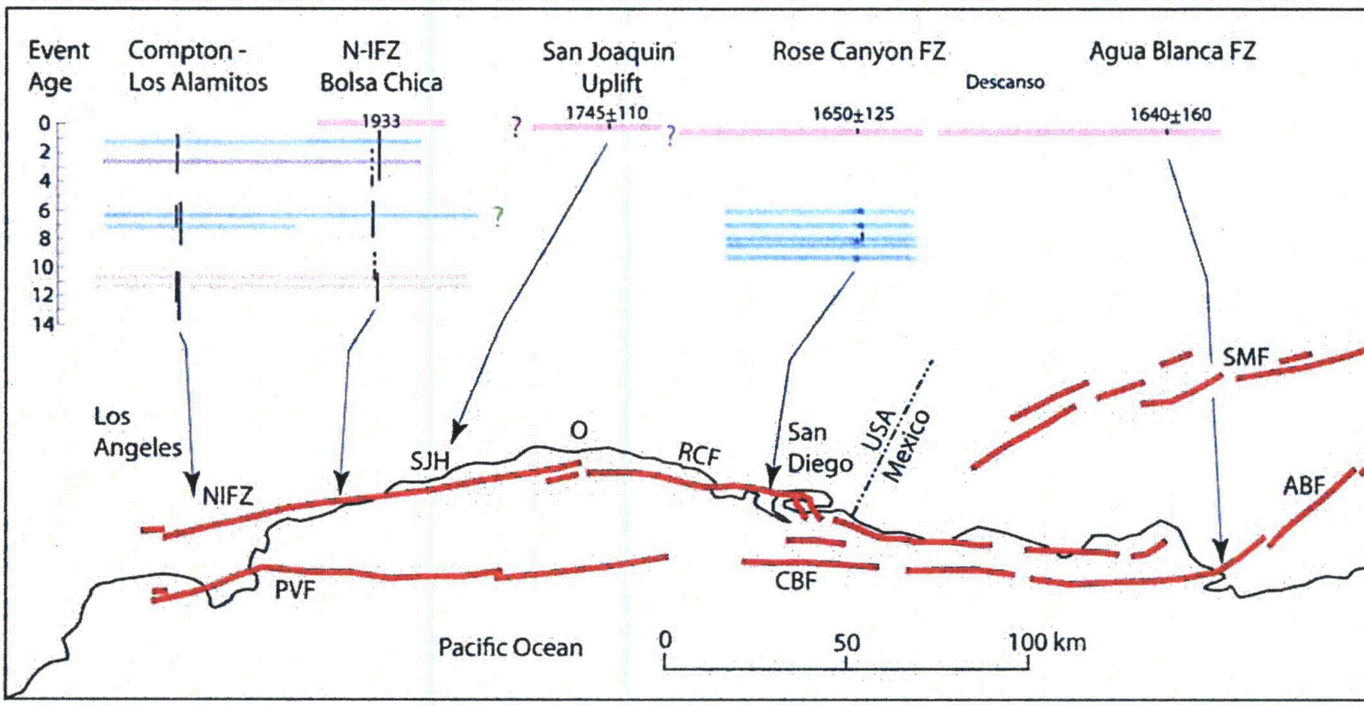
NOTE: Note the deflected channels incised into the Qt2 surface, which is interpreted to be last the interglacial terrace based on its elevation (from Rockwell, 2010).

GeoPentech Geotechnical & Geoscience Consultants By Rockwell (2010)	INTERPRETED 1941 AERIAL PHOTOGRAPHY OF THE OLD TOWN AREA OF SAN DIEGO	FIGURE A2-4
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



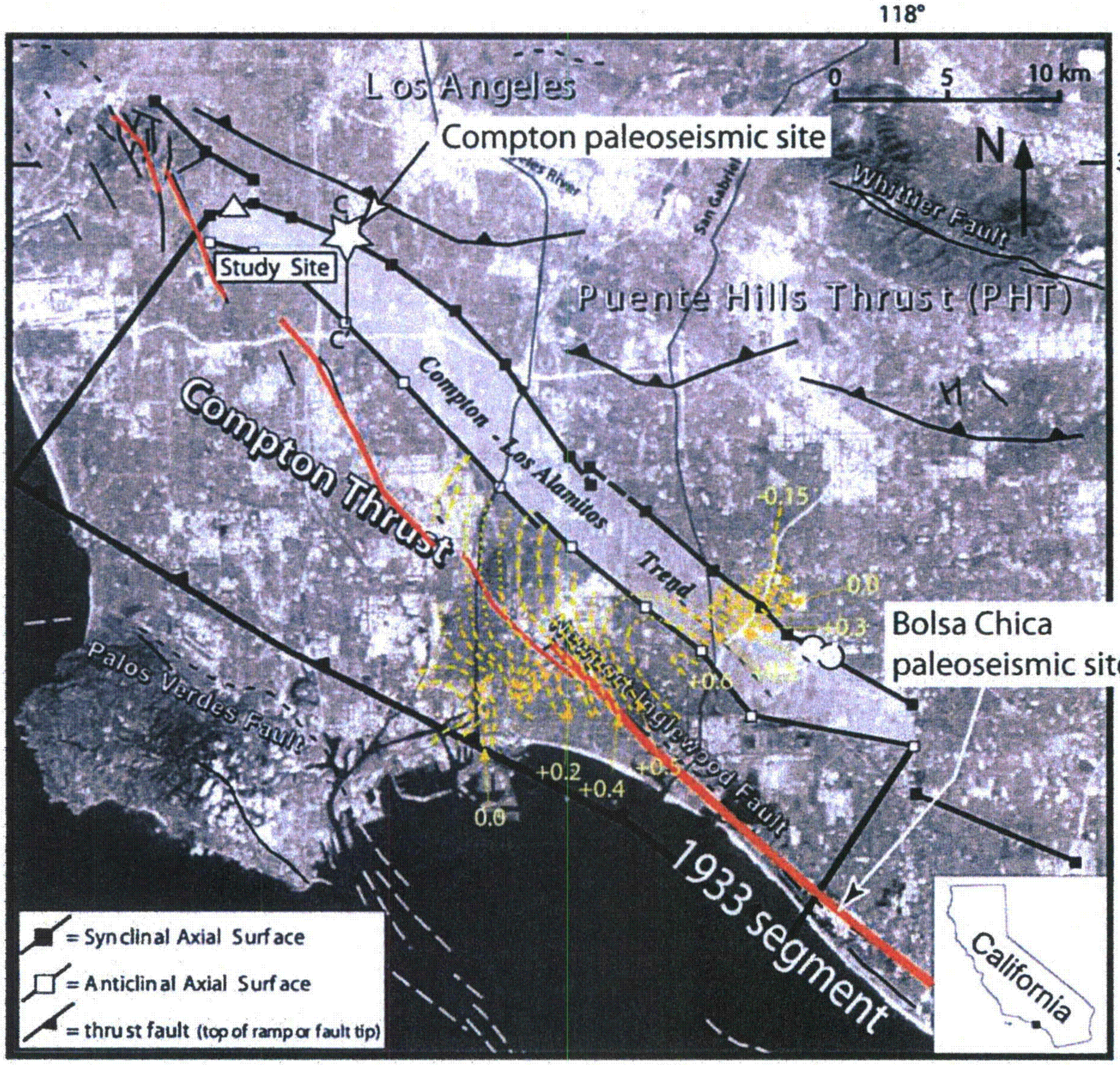
NOTE: Also shown is the smaller step at Oceanside with the change in fault strike. SAFZ - San Andreas fault zone; SJFZ - San Jacinto fault zone; IF - Imperial fault; CPF - Cerro Prieto fault; LSF - Laguna Salada fault; NIFZ - Newport- Inglewood fault zone; RCF - Rose Canyon fault; CF - Calabasas fault; VF - Vallecitos fault; SMFZ - San Miguel fault zone; THF - Tres Hermanes fault; ABFZ - Agua Blanca fault zone; CBFZ - Coronado Bank fault zone; DFZ - Descanso fault zone; SDTF - San Diego Trough fault; SCFZ - San Clemente fault zone; SIFZ - San Isidro fault zone.

GeoPentech By Rockwell (2010)	**MAP SHOWING HOW STEP-OVER WIDTH WAS MEASURED FOR THE SAN DIGEO BAY STEP**	FIGURE A2-5
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



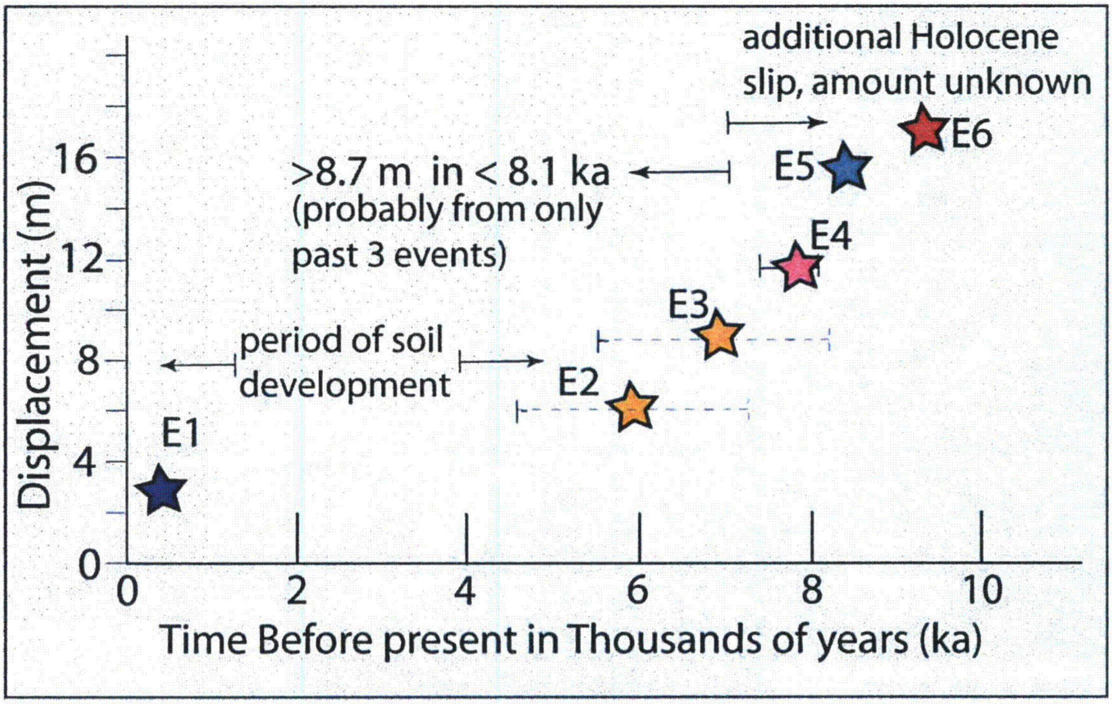
NOTE: Results from paleoseismic studies for the Agua Blanca, Rose Canyon, San Joaquin Hills, Newport-Inglewood, and Compton faults (from Grant and Rockwell, 2002; Grant et al., 1997, Leon et al., 2009).

GeoPentech By Rockwell (2010)	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	PALEOSEISMICITY FOR NI/RC FAULT ZONE	FIGURE A2-6



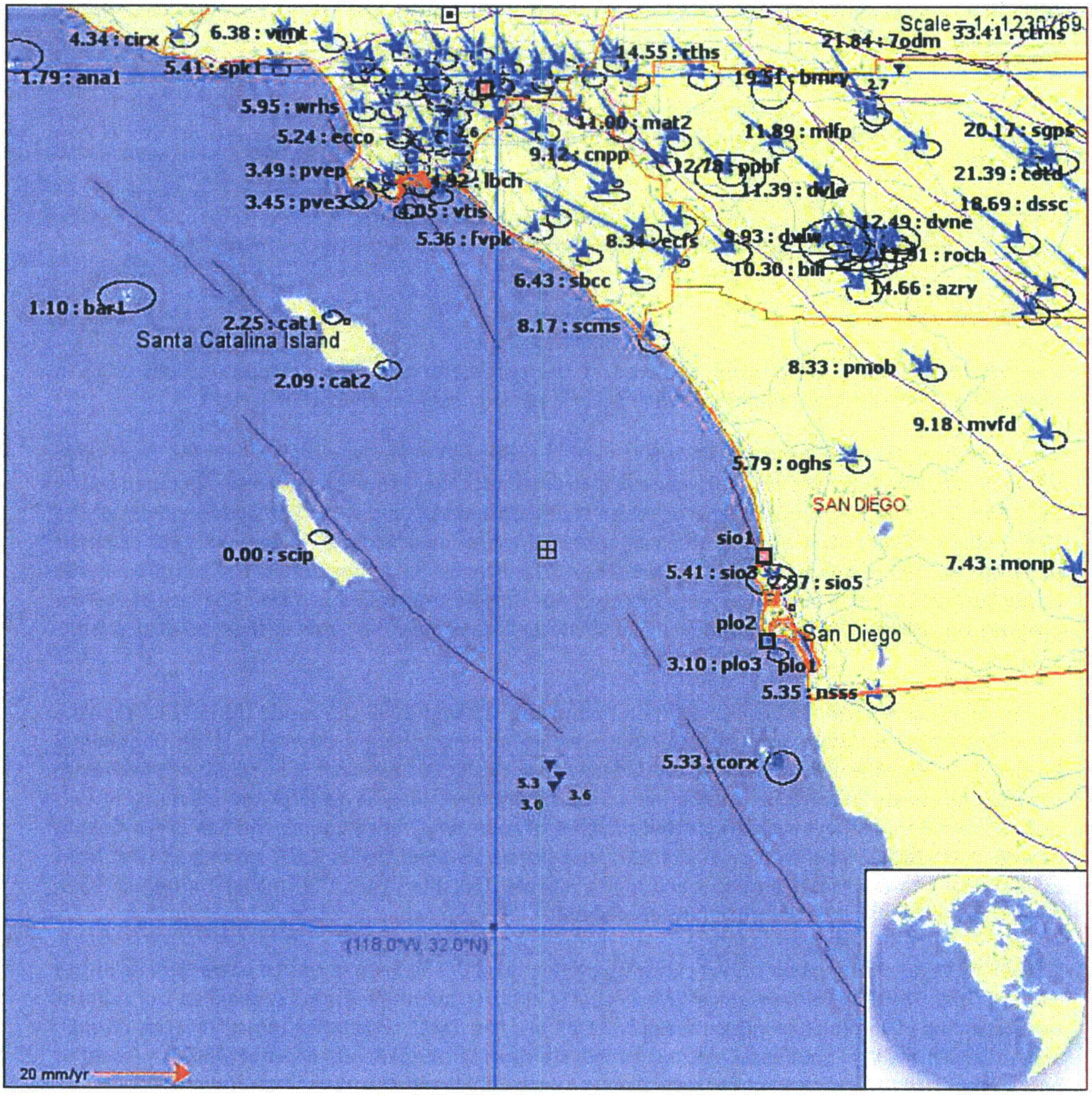
NOTE: Location figure from Leon et al. (2009), showing their Compton paleoseismic site. The bolded red line is the inferred segment that ruptured in 1933 (Barrows, 1974), along with the area that sustained uplift in the 1933 earthquake, based on leveling data (Barrows, 1974). Maximum uplift was documented as more than 60 cm, with the locus between the Newport-Inglewood and Los Alamitos structures, supporting Wright's (1991) interpretation that the Compton-Los Alamitos trend is deformation associated with an oblique, high-angle fault.

GeoPentech Geotechnical & Geoscience Consultants By Rockwell (2010)	LOCATION FIGURE FROM LEON ET AL. (2009)	FIGURE A2-7
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



NOTE: Timing of surface ruptures at Rose Creek, assuming that the strong soil development across the early Holocene fault splays accurately represents a lack of activity for several thousand years (from Rockwell, 2010a).

GeoPentech By Rockwell (2010)	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	TIMING OF SURFACE RUPTURES AT ROSE CREEK	FIGURE A2-8



NOTE: GPS velocity field of the southern California Borderland, plotted with San Clemente Island as the reference frame (plotted in 2005 from the SCIGN web page).

GeoPentech Geotechnical & Geoscience Consultants By Rockwell (2010)	GPS VELOCITY FIELD OF THE SOUTHERN CALIFORNIA BORDERLAND	FIGURE A2-9
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	

APPENDIX A – ATTACHMENT A-3

SEISMIC SOURCE CHARACTERISTICS OF INNER CALIFORNIA BORDERLAND'S BLIND THRUST FAULT SYSTEMS

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Department of Earth and Planetary Sciences Harvard University, Cambridge, MA

INTRODUCTION

The following document has been prepared at the request of Southern California Edison (SCE) in consultation with technical members of their Seismic Hazard Assessment Program (SHAP).

Active thrust faults have long been known to exist in southern California, particularly in the Transverse Range Province. Awareness of the seismic risk associated with these thrust faults was heightened by the 1971 San Fernando (M_W 6.6) Earthquake, which resulted from slip on the San Fernando segment of the Sierra Madre Thrust Fault System; slip that ruptured the ground surface. Later, the 1987 Whittier Narrows (M_L 5.9) and the 1994 Northridge (M_W 6.7) earthquakes demonstrated the seismic hazards posed by these 'blind' thrust faults; slip that does not rupture the ground surface. The lack of surface ruptures on 'blind' thrust faults hinders our ability to locate them and assess their level of seismic activity.

The reverse/thrust focal mechanism solution tied to the offshore 1986 Oceanside (M_L 5.3) Earthquake demonstrated that active blind thrust faults also exist in southern California's Inner Continental Borderland. This offshore earthquake, combined with our extensive research of hundreds of proprietary oil industry marine geophysical seismic reflection survey lines, lead us to infer the presence of two distinct, active thrust fault systems located offshore of southern Orange County and San Diego County (Rivero et.al., 2000). As shown on Figure A3-1, the Oceanside Blind Thrust (OBT) extends at least from Laguna Beach to the Mexican border and may dip under the shoreline. The smaller Thirty-mile Bank Blind Thrust (TMBT) lies to the west, farther offshore.

Following is a brief discussion of our current understanding of the seismic source characteristic of the OBT and the TMBT developed since Rivero et.al. (2000). This briefing also summaries our current understanding of the relationship between the OBT and the TMBT with other thrust, reverse, normal, and strike-slip faults in southern California's Inner Continental Borderland. Most of what is presented herein is derived from what has been described in Rivero (2004) and Rivero and Shaw (in press).

Specifically, in this briefing we summarize:

1) Constraints on the location of the OBT and TMBT and our assessment of their level of seismic activity;
2) Our current understanding and weightings of the seismic characteristics of these two fault systems;

3) The logic tree developed to facilitate incorporating, particularly the OBT fault systems into SCE's Probabilistic Seismic Hazard Assessment (PSHA) and Probabilistic Tsunami Hazard Assessment (PTHA) updates for the San Onofre Nuclear Generating Station (SONGS);
4) The key remaining uncertainties regarding each fault's seismic source characteristics; and
5) Our recommendations for future efforts to resolve these key remaining uncertainties. A list of the references flagged herein is included at the end of this briefing document.

PRESENCE AND LEVEL OF ACTIVITY

In Rivero (2004) and Rivero and Shaw (in press) we supplemented the information provided in Rivero et.al., (2000) with more details on the various data supporting the presence and activity of the OBT and TMBT and their connections with the offshore high-angle, strike slip faults; the latter including the Newport-Inglewood (NI), Rose Canyon (RC), and San Diego Trough (SDT) faults.

These data include:

a) High-resolution seismic reflection data that image the OBT and TMBT. These faults are defined by deep, shallow dipping, seismic reflections off the coast of southern California underlying folded and faulted sediments. The youngest of these sediments are inferred to be at least Plio-Pleistocene in age (some apparently displacing the sea floor).
b) Balanced and restored cross sections that document significant contraction or shortening on these structures since the Pliocene (such as the ~2.2 to 2.7 km across the OBT within the last ~1.8 – 2.4 million years).
c) Earthquake epicenter/hypocenter/focal mechanisms, particularly the Oceanside 1986 M_L 5.3 event, which occurred between San Clemente Island and Oceanside, CA and ruptured the TMBT. In addition, the 1986 Coronado Bank earthquake events, max M_L 3.7, which occurred offshore of Point Loma in August 1986 (Astiz and Shearer, 2000), were incorporated in our analysis;
d) Elevated marine terraces along the Orange/San Diego County's shoreline; and
e) GPS data from the SCEC Crustal Motion Map that Kier and Mueller (1999) used to calculate the components of motion perpendicular to the offshore thrust fault traces. Rivero 2005 used the maximum of these station values, minus the slip rate derived for the OBT, to bracket the slip rate on the Thirty-mile Bank fault. Our sense is that these geodetic data are poorly constrained, largely due to the lack of offshore data coverage. Thus, there is a large uncertainty associated with this rate determination, but at present we simply lack another means to estimate this rate.

SEISMIC CHARACTERISTICS

Figure A3-1 provides a map of the OBT and TMBT and their associated hanging wall and footwall subsidiary faults, as modified from Rivero (2004). Also modified from Rivero (2004), Figure A3-2 summarizes the various rupture models considered for these faults. Figure A3-3 provides a more simplified version of the fault map presented on Figure A3-1. This more simplified map was used to obtain the representative three dimensional coordinates for the OBT, TMBT and their associated splay faults relative to the location of the SONGS for input into the PSHA program (Abrahamson, 2010).

The table presented in Figure A3-4 provides a complete listing of our current estimates of the OBT's and TMBT's seismic source characteristics. In addition, we provide seismic source characteristics of other thrust, reverse, normal, and strike-slip faults in the region that may rupture in conjunction with the OBT and TMBT Fault Systems. Each row of the table represents different individual or multi-segment combinations of plausible rupture scenarios, keyed to the schematic drawings of the four alternative rupture models presented in Figure A3-2.

The rupture area (km^2) for each plausible rupture scenario listed in Figures A3-3 and A3-4 was estimated based on the 3-D mapping of the fault in the SCEC Community Fault Model that we have developed (Plesch et al., 2007), assuming a seismogenic depth > 5 km and <17 km. The resulting maximum magnitude earthquake was then calculated using the rupture area versus magnitude relationships developed by Wells and Coppersmith (1994).

The slip rate was estimated for the OBT based on measures of fault offsets and uplift using the marine geophysical seismic reflection survey data and estimates of the ages of the deformed geologic formations. Using the estimated slip rates we then calculated recurrence intervals of the maximum magnitude earthquake for each particular rupture scenario using Wells & Coppersmith (1994) and Shaw and Suppe (1996).

The slip rate for the TMBT was estimated from limited GPS data, as discussed above. We have no constrains on the slip rate of the SDT fault, although it appears to be active based on offsets of near seafloor horizons.

The slip rate on the Carlsbad Fault was estimated by Rivero (2004) based on a range of dip-slip values (0.4 to 0.6 km) using two alternative structural models. The rates are derived using maximum and minimum ages (2.4 and 1.8 mya, respectively) for the initiation of faulting and folding, as defined by patterns of syntectonic (growth) sediments.

Slip rate estimates for the offshore extensions of the NI and RC right-lateral strike-slip faults were based on slip rates assigned to the on-shore traces of these faults from CGS (2002).

LOGIC TREE FOR PSHA/PTHA

Our sense is that these alternative rupture models represent a range of possible scenarios. In reality, however, some may not occur. If more than 1 of these alternatives does occur (which seems plausible), it implies that various fault segment rupture in different types of earthquakes. Thus, the alternatives attempt to capture both epistemic and aleatory uncertainty.

The first step in utilizing the above seismic source characterization of the OBT, TMBT and related subsidiary faults in the SONGS PSHA involved the preparation of the logic tree presented on Figure A3-5. This logic tree was used to accommodate both the epistemic and aleatory uncertainty in the seismic source characteristics (SSC) of the various alternative rupture models. A digital file of this logic tree is also provided in the attached CD.

In terms of our confidence in the reality of the various branches of the logic tree presented on Figure A3-5, we feel it is acceptable to apply equal weights to accommodate the epistemic uncertainty in both model 3 and 4, and a reduced weight for model 2. Although this is a subjective assessment, we would suggest that model 2 should be weighted substantially lower than model 3 or 4 (by a factor 4 or more).

Our reasoning for this weighting is that no viable structural model has been presented to explain the observed slip on the Oceanside thrust is driven by motion on the strike-slip faults. Therefore on a percentage basis, in terms of our best guess, something like 45% for model 3, 45% for model 4, and 10% for model 2, would be a reasonable fit.

We recognize that others believe that right-lateral strike slip faults (model 1) dominate the tectonics off-shore of Orange and San Diego Counties. However, based on the currently available data, we would assign a weight of '0' to rupture model 1 on Figure A3-5. As we stated above, rupture model 1 is not kinematically compatible with the large amount of displacement we document on the OBT Fault. Thus, we believe that the seismogenic potential of the strike-slip faults is represented most effectively in models 2, 3, or 4.

Our percentage weightings applied to the alternative linkage hypotheses for both single and complex strike-slip and thrust earthquake sources in rupture models 3 and 4, are also shown on Figure A3-5. These best guess percentages also reflect on the current epistemic uncertainty of the existing data regarding the connection of the various possible rupture linkages within a seismogenic depth > 5 km and <17 km.

Based on the available data and interpretations there are 67 combinations of fault rupture segments as shown on Figure A3-5. Those branches of the logic tree that reflect the "either/or" epistemic uncertainty of the data are highlight with blue colored lines. The "sometime this way/ sometimes that way" aleatory uncertainty in the data is highlighted in the logic tree by orange line boxes.

Model 1 (0% weighting) focuses the remaining portion of this Appendix on the remaining three OBT models. The possibility of Model 1 as a likely seismic source is discussed in more detail in the other subsections of Appendix A.

Model 2 (10% weighting) reflects two separate alternative seismic sources, i.e., the high angle, strike-slip NI and RC faults. Either these two sources is reflected as 'sometimes' rupturing only on a single segment and 'sometimes' rupturing on multisegments, both onshore and offshore. Model 2 also accommodates the aleatory possibility that the OBT will rupture as a southwest vergent subsidiary fault off of either the NI or the RC faults' rupture. Using the magnitude and slip rate calculations listed in Figure A3-4, the resulting earthquake recurrence was calculated using the Wells and Coppersmith, (1994) Maximum Magnitude recurrence models.

Model 3 (45% weighting) reflects three separate alternative seismic sources, i.e., the onshore/near shore segments of the NI and RC strike-slip faults and the OBT. The OBT has two epistemic branches reflecting the uncertainty as to its extent on-shore to the north of Dana Point and under the San Joaquin Hills. This uncertainty impacts the source area/maximum magnitude calculation, but otherwise the make-up of the logic tree is the same for the branch "North of Dana Point" as is for the branch "South of Dana Point". Using the "South of Dana Point" branch as an example for Model 3, the 4 "linkage" options, i.e., 3a, $3b_1$, $3b_2$, and 3c and their corresponding epistemic weightings are considered. Then under each of these four linkage alternatives, the single and multiple thrust fault/hanging and footwall subsidiary fault aleatory randomness is accommodated. Then, as was explained in the Model 2 discussion, for each of these rupture models the corresponding slip rates and recurrence calculations are provided.

Model 4 (45% weighting) reflects a similar logic three as Model 3, but with fewer branches to reflect the lack of a footwall faults in Model 4 in comparison with Model 3. However, two differences exist between Model 3 and Model 4 rupture scenarios. The first of these differences is reflected by "linkage 4b" were no seismogenic links exist between the high-angle strike-slip fault in the hanging wall above the OBT because of its depth below the seismic zone (> 17 km). In this situation the hanging wall, high angle, strike-slip fault ruptures as an independent source in addition to the thrust fault source. The second Model 4 versus Model 3 variation was to accommodate the presence of the Carlsbad Thrust Fault in the hanging wall above the OBT. The Carlsbad fault rupture scenario was not part of Model 3 because it presence only in the hanging wall was clearly supported by the marine seismic reflection data, thus only fitting Model 4.

KEY REMAINING UNCERTAINTIES

The key uncertainties associated with representing these potential seismic sources in the SONGS's PSHA result from the lack of good constraints on the fault slip rates and the inability to distinguish between the several single and multi-segment rupture scenarios that are considered. Specifically, it is unclear whether the shallow dipping thrust faults (such as the OBT) are the primary seismic source faults, with the steeply dipping, right-lateral, strike-slip faults, such as the NI or the RC faults, being subsidiary, or whether the steep, strike-slip faults are the primary seismic sources, and the thrust faults are subsidiary.

Unfortunately this uncertainty continues to exist. The TMBT fault is locally imaged in the seismic reflection to the east of its intersection of the San Diego Trough strike-slip fault. This, combined with the location and focal mechanism of the 1986 Oceanside earthquake, imply that the TMBT is a continuous, active structure. This favors models 3 and 4. None of the seismic reflection profiles we examined, however, clearly imaged subsurface conditions at the depths and locations necessary to resolve the critical interactions of the OBT and NI-RC system. The OBT is not imaged in these locations because it juxtaposes basement on top of basement rocks. Thus, no significant impedance boundary exists, and the fault cannot be imaged by the seismic data.

Regarding fault activity and slip rates, the TMBT is clearly active based on the 1986 Oceanside earthquake. However, its recent (Holocene) slip rate is largely unconstrained, as is the slip rate for the San Diego Trough strike-slip fault. We simply lack the ability to measure direct fault offsets and/or to have constraints on the ages of offset horizons given the lack of well data in this area. The evidences for activity of the OBT are more indirect. Perhaps the best constrains on recent activity of the OBT come from folded and offset horizons at or near the seafloor. However, lacking direct age control for these young sediments limits our ability to constrain how recently the fault has rupture and its slip rate. Association of the OBT and the San Joaquin Hills thrust, combined with the patterns of uplifted coastal marine terraces, further support fault activity.

RECOMMENDATIONS TOWARDS RESOLVING REMAINING UNCERTAINTIES

At the depths and locations where data is necessary to resolve the uncertainty discussed above regarding the intersection between the NI/RC and the OBT, the faults are within the basement rocks and the velocity contrast/acoustic impedance of the basement rocks either side of where these faults are inferred to be interfacing is not likely to be significant enough to produce adequate reflectors in the marine geophysical seismic reflection surveys. As such, even if environmental hurdles to future deep seismic surveys are overcome, it is doubted whether high energy, deep penetrating 2-D or 3-D seismic surveys can retrieve the necessary data to be able to unequivocally resolve this particularly important uncertainty.

In lieu of this data, the following is recommended to better define the extent of the OBT and the TMBT and to more precisely estimate their late Pleistocene and Holocene activity.

- High-resolution side-scan sonar and seismic reflection imaging of seafloor deformation combined with sediment sampling and dating, would likely provide better constraints on activity and slip rates for the OBT, TMBT, and San Diego Trough strike-slip fault (highest priority). Regarding recommended sites of future studies, Figure A3-6 highlights three possible study regions. Clearly, we would need to do a more thorough evaluation of current data to confirm the appropriateness of each site, and the particular types of data (side-scan sonar, high-res seismic) that would be most useful. Nevertheless, region 1 would target improving our understanding of the along strike continuity of the Oceanside and San Joaquin Hills structures, as well as the offshore Newport-Inglewood fault. Region 2 would target defining a slip rate on the Carlsbad fault based on the discrete near-surface fold, as well as perhaps a slip rate on the offshore Rose Canyon fault system. Region 3 would target the San Diego Trough fault in a releasing bend, thereby constraining the fault slip rate.
- Precise relocation of offshore seismicity using newly available 3D velocity models for the region and advanced relocation methods. Better earthquake locations will improve our ability to establish which fault segments are active, and to define better their subsurface geometries.
- Evaluation of current geodetic observations to improve constraints on shortening and strike-slip rates.

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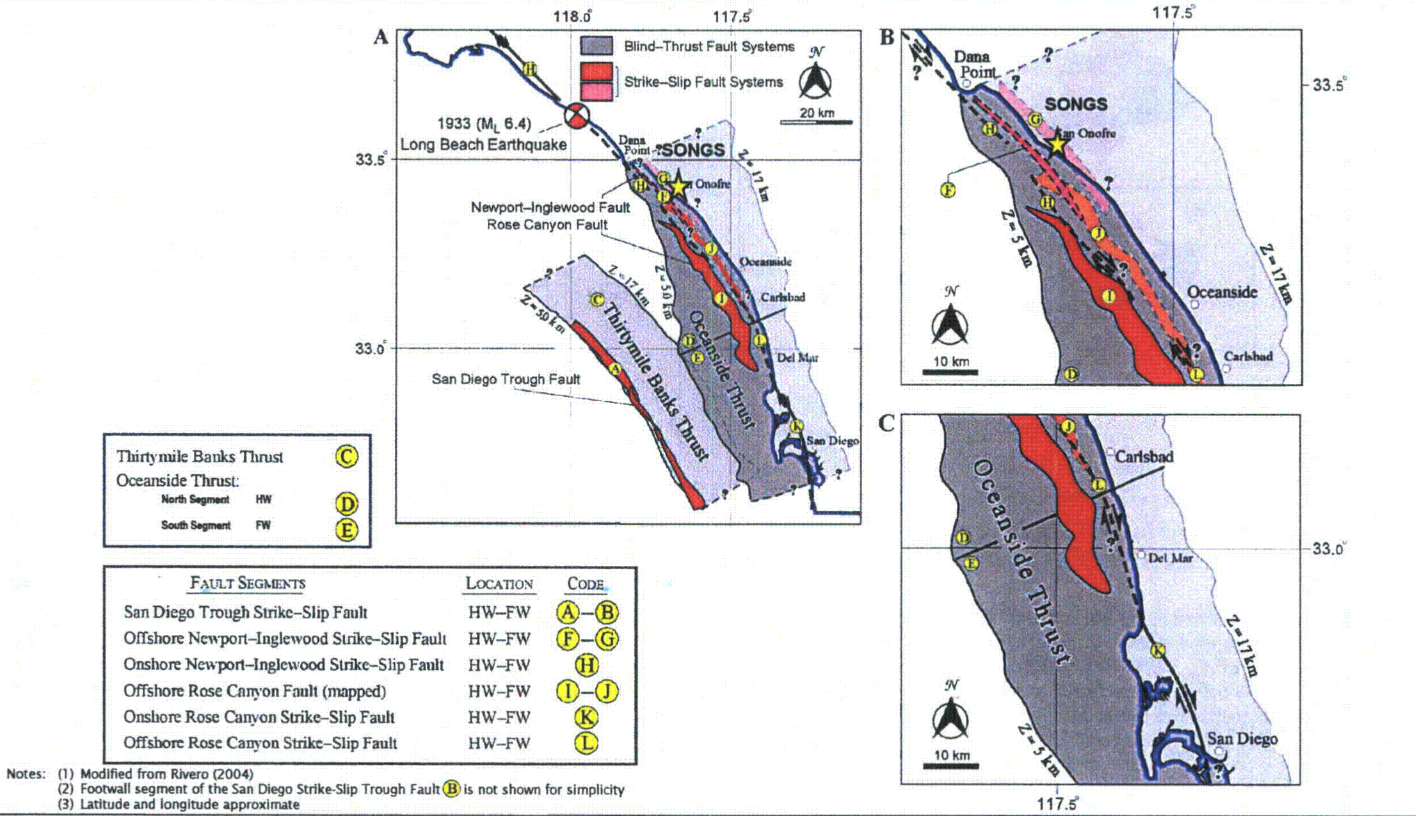
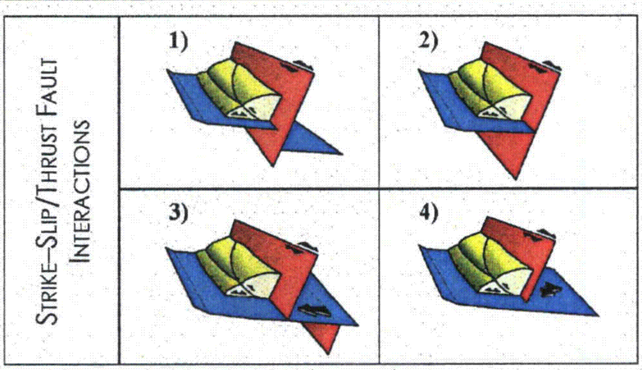


Notes: (1) Modified from Rivero (2004)
(2) Footwall segment of the San Diego Strike-Slip Trough Fault (B) is not shown for simplicity
(3) Latitude and longitude approximate

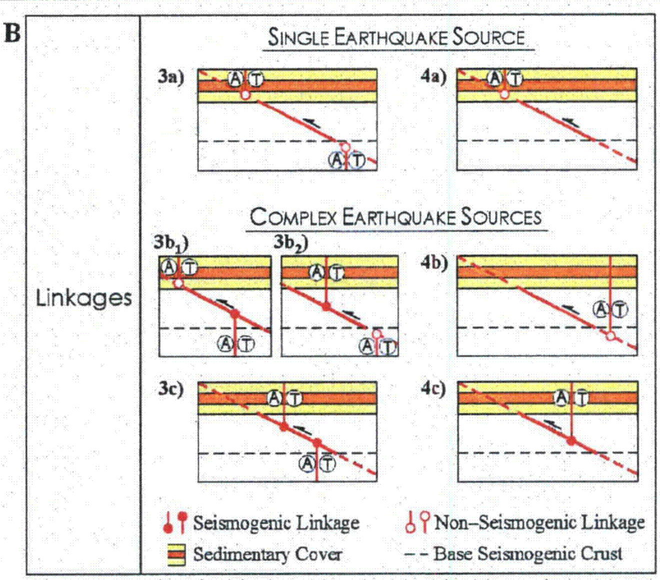
GeoPentech By Shaw and Plesch (2010)	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	INNER SOUTHERN CALIFORNIA CONTINENTAL BORDERLANDS BLIND THRUST FAULT SYSTEMS	FIGURE A3-1

A



3a) Non–Seismogenic linkages with 1 earthquake source
3b) Hybrid Seismogenic linkages with 2 earthquake sources
3c) Seismogenic linkages with 3 earthquake sources
4a) Non–Seismogenic linkage with 1 earthquake source
4b) Non–Seismogenic linkage with 2 earthquake sources
4c) Seismogenic linkage with 2 earthquake sources

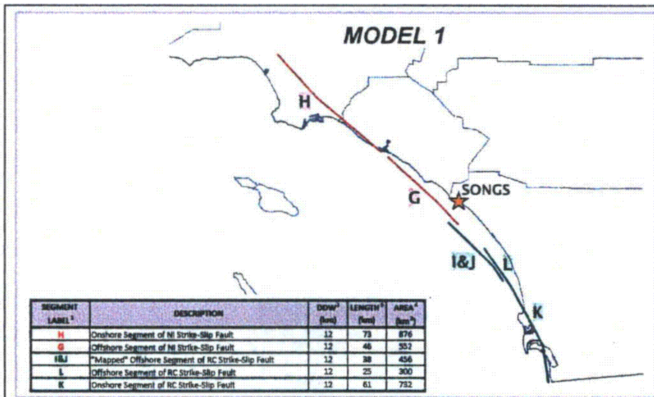
B



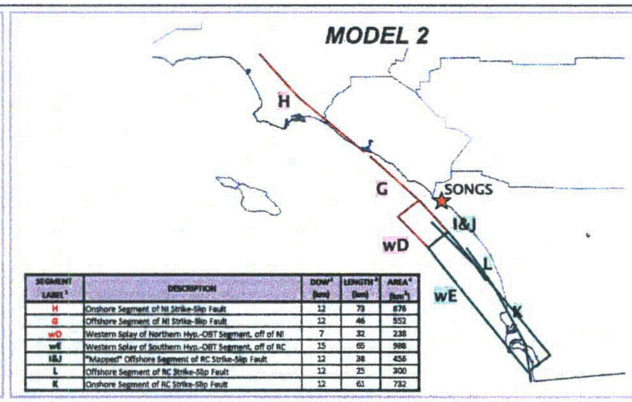
(A) Schematic representation of different structural scenarios considered in this study for strike–slip and blind–thrust fault interactions [modified from Rivero *et al.*, 2000]. **(B)** Geometric linkages between strike–slip and blind–thrust faults defined for preferred structural scenarios 3.25A3 and 3.25A4. The type of geometric linkage and their position relative to the depth of the sediments and the seismogenic crust determine the seismogenic potential of the faults and the type of earthquake source.

Notes: Modified from Rivero (2004)

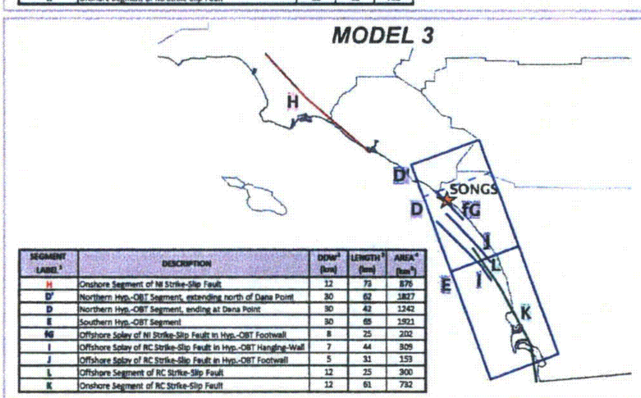
GeoPentech By Shaw and Plesch (2010)	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	ALTERNATIVE RUPTURE MODELS AND LINKAGES BETWEEN BLIND THRUST AND RIGHT LATERAL STRIKE-SLIP SYSTEMS	FIGURE A3-2



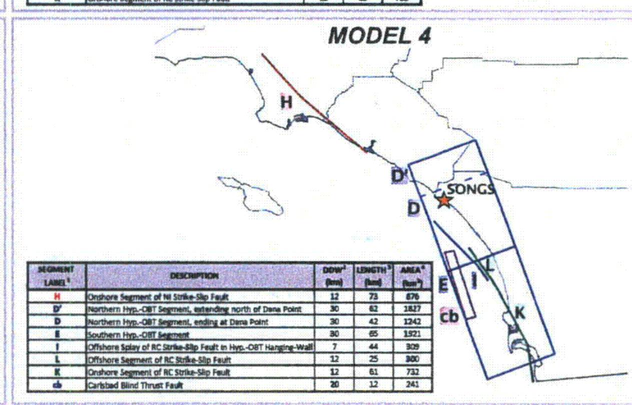
SEGMENT LABEL[1]	DESCRIPTION	DDW[2] (km)	LENGTH[3] (km)	AREA[4] (km²)
H	Onshore Segment of NI Strike-Slip Fault	12	73	876
G	Offshore Segment of NI Strike-Slip Fault	12	46	552
I&J	"Mapped" Offshore Segment of RC Strike-Slip Fault	12	38	456
L	Offshore Segment of RC Strike-Slip Fault	12	25	300
K	Onshore Segment of RC Strike-Slip Fault	12	61	732



SEGMENT LABEL[1]	DESCRIPTION	DDW[2] (km)	LENGTH[3] (km)	AREA[4] (km²)
H	Onshore Segment of NI Strike-Slip Fault	12	73	876
G	Offshore Segment of NI Strike-Slip Fault	12	46	552
wD	Western Splay of Northern Hyp.-OBT Segment, off of NI	7	32	238
wE	Western Splay of Southern Hyp.-OBT Segment, off of RC	15	65	988
I&J	"Mapped" Offshore Segment of RC Strike-Slip Fault	12	38	456
L	Offshore Segment of RC Strike-Slip Fault	12	25	300
K	Onshore Segment of RC Strike-Slip Fault	12	61	732



SEGMENT LABEL[1]	DESCRIPTION	DDW[2] (km)	LENGTH[3] (km)	AREA[4] (km²)
H	Onshore Segment of NI Strike-Slip Fault	12	73	876
D'	Northern Hyp.-OBT Segment, extending north of Dana Point	30	62	1827
D	Northern Hyp.-OBT Segment, ending at Dana Point	30	42	1242
E	Southern Hyp.-OBT Segment	30	65	1921
fG	Offshore Splay of NI Strike-Slip Fault in Hyp.-OBT Footwall	8	25	202
I	Offshore Splay of RC Strike-Slip Fault in Hyp.-OBT Hanging-Wall	7	44	309
J	Offshore Splay of RC Strike-Slip Fault in Hyp.-OBT Footwall	5	31	153
L	Offshore Segment of RC Strike-Slip Fault	12	25	300
K	Onshore Segment of RC Strike-Slip Fault	12	61	732



SEGMENT LABEL[1]	DESCRIPTION	DDW[2] (km)	LENGTH[3] (km)	AREA[4] (km²)
H	Onshore Segment of NI Strike-Slip Fault	12	73	876
D'	Northern Hyp.-OBT Segment, extending north of Dana Point	30	62	1827
D	Northern Hyp.-OBT Segment, ending at Dana Point	30	42	1242
E	Southern Hyp.-OBT Segment	30	65	1921
I	Offshore Splay of RC Strike-Slip Fault in Hyp.-OBT Hanging-Wall	7	44	309
L	Offshore Segment of RC Strike-Slip Fault	12	25	300
K	Onshore Segment of RC Strike-Slip Fault	12	61	732
cb	Carlsbad Blind Thrust Fault	20	12	241

Notes:

[1] Labels modified from Figure A-2-1

[2] Assuming 5km to 17km Seismogenic Depth

[3] Based on Rivero (2004)

[4] Calculated based on DDW and Length

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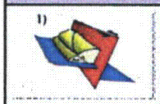
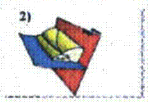
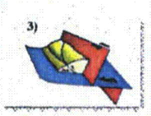
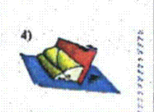
SEISMIC HAZARD ASSESSMENT PROGRAM

SIMPLIFIED GEOMETRY AND SEGMENTATION FOR BLIND THRUST AND RIGHT LATERAL STRIKE-SLIP SYSTEMS

FIGURE A3-3

KINEMATIC MODEL	SEISMIC SOURCE	OBT LIMIT	LINKAGE	SINGLE SEGMENT					MULTI SEGMENT				
				SEGMENTS	RUPTURE AREA (KM^2)	MAX MAG[1] (M)	SLIP RATE[2] (mm/yr)	RECURRENCE[3] (yr)	SEGMENTS	RUPTURE AREA (KM^2)	MAX MAG[1] (M)	SLIP RATE[2] (mm/yr)	RECURRENCE[3] (yr)
1) 	NI Strike-Slip			G	552	6.8	1.5+/-0.5	390 - 780	G + H	1428	7.2	1+/-0.5	980 - 2940
				H	876	7.0	1+/-0.5	710 - 2140					
	RC Strike-Slip			I&J	456	6.7	1.07+/-0.03	600 - 640	I&J + K	1188	7.1	1.07+/-0.03	1140 - 1210
				K	732	6.9	1.07+/-0.03	830 - 880	K + L	1032	7.0	1.07+/-0.03	970 - 1030
				L	300	6.5	1.07+/-0.03	440 - 470	L + I&J	756	6.9	1.07+/-0.03	830 - 880
				-	-	-	-	-	I&J + K + L	1488	7.2	1.07+/-0.03	1340 - 1420
2) 	NI Strike-Slip			G&wD	790	6.9	1.02+/-0.14	790 - 1040	G&wD + H	1666	7.2	1.02+/-0.14	1270 - 1670
				H	876	7.0	1+/-0.5	710 - 2140					
	RC Strike-Slip			I&J&wE	1444	7.2	0.82+/-0.12	1570 - 2100	I&J&wE + K	2176	7.3	0.82+/-0.12	1840 - 2470
				K	732	6.9	1.07+/-0.03	830 - 880	K + L	1032	7.0	1.07+/-0.03	970 - 1030
				L	300	6.5	1.07+/-0.03	440 - 470	L + I&J&wE	1744	7.2	0.82+/-0.12	1570 - 2100
				-	-	-	-	-	I&J&wE + K + L	2476	7.4	0.82+/-0.12	2150 - 2890
3) 	NI Strike-Slip			H	876	7.0	1+/-0.5	710 - 2140	-	-	-	-	-
	RC Strike-Slip			K	732	6.9	1.07+/-0.03	830 - 880	K + L	1032	7.0	1.07+/-0.03	970 - 1030
				L	300	6.5	1.07+/-0.03	440 - 470					
	Oceanside Thrust	Ends at Dana Point (D)	3a	D	1242	7.1	1.02+/-0.14	1080 - 1430	D + E	3163	7.5	1.02+/-0.14	2040 - 2690
				E	1921	7.3	0.82+/-0.12	1840 - 2470					
			3b1	D&fG	1444	7.2	1.02+/-0.14	1270 - 1670	D&fG + E&J	3518	7.6	1.74+/-0.2	1430 - 1810
				E&J	2074	7.3	0.82+/-0.12	1840 - 2470					
			3b2	D	1242	7.1	1.02+/-0.14	1080 - 1430	D + E&I	3472	7.5	1.74+/-0.2	1220 - 1540
				E&I	2230	7.4	0.82+/-0.12	2150 - 2890					
			3c	D&fG	1444	7.2	1.02+/-0.14	1270 - 1670	D&fG + E&I&J	3827	7.6	1.74+/-0.2	1430 - 1810
				E&I&J	2383	7.4	0.82+/-0.12	2150 - 2890					
		Extends North of Dana Point (D')	3a	D'	1827	7.3	1.02+/-0.14	1490 - 1960	D' + E	3748	7.6	1.02+/-0.14	2400 - 3160
				E	1921	7.3	0.82+/-0.12	1840 - 2470					
			3b1	D'&fG	2029	7.3	1.02+/-0.14	1490 - 1960	D'&fG + E&J	4103	7.6	1.74+/-0.2	1430 - 1810
				E&J	2074	7.3	0.82+/-0.12	1840 - 2470					
			3b2	D'	1827	7.3	1.02+/-0.14	1490 - 1960	D' + E&I	4057	7.6	1.74+/-0.2	1430 - 1810
				E&I	2230	7.4	0.82+/-0.12	2150 - 2890					
			3c	D'&fG	1444	7.2	1.02+/-0.14	1270 - 1670	D'&fG + E&I&J	4412	7.6	1.74+/-0.2	1430 - 1810
				E&I&J	2383	7.4	0.82+/-0.12	2150 - 2890					
4) 	NI Strike-Slip			H	876	7.0	1+/-0.5	710 - 2140	-	-	-	-	-
	RC Strike-Slip			K	732	6.9	1.07+/-0.03	830 - 880	K + L	1032	7.0	1.07+/-0.03	970 - 1030
				L	300	6.5	1.07+/-0.03	440 - 470					
	Oceanside Thrust	Ends at Dana Point (D)	4b	D	1242	7.1	1.02+/-0.14	1080 - 1430	D + E	3163	7.5	1.02+/-0.14	2040 - 2690
				E	1921	7.3	0.82+/-0.12	1840 - 2470					
				I	309	6.5	1.07+/-0.03	440 - 470					
			4c	D	1242	7.1	1.02+/-0.14	1080 - 1430	D + E&I	3472	7.5	1.74+/-0.2	1220 - 1540
				E&I	2230	7.4	0.82+/-0.12	2150 - 2890					
		Extends North of Dana Point (D')	4b	D'	1827	7.3	1.02+/-0.14	1490 - 1960	D' + E	3748	7.6	1.02+/-0.14	2400 - 3160
				E	1921	7.3	0.82+/-0.12	1840 - 2470					
				I	309	6.5	1.07+/-0.03	440 - 470					
			4c	D'	1827	7.3	1.02+/-0.14	1490 - 1960	D' + E&I	4057	7.6	1.74+/-0.2	1430 - 1810
				E&I	2230	7.4	0.82+/-0.12	2150 - 2890					
	Carlsbad Thrust			cb	241	6.4	0.25+/-0.08	1250 - 2430	-	-	-	-	-

Notes:

[1]Maximum Magnitude based on Wells & Coppersmith (1994)

[2]Value estimated by Rivero (2004) or Shaw & Plesch (2010)

[3]Recurrence interval based on Shaw & Suppe (1996)

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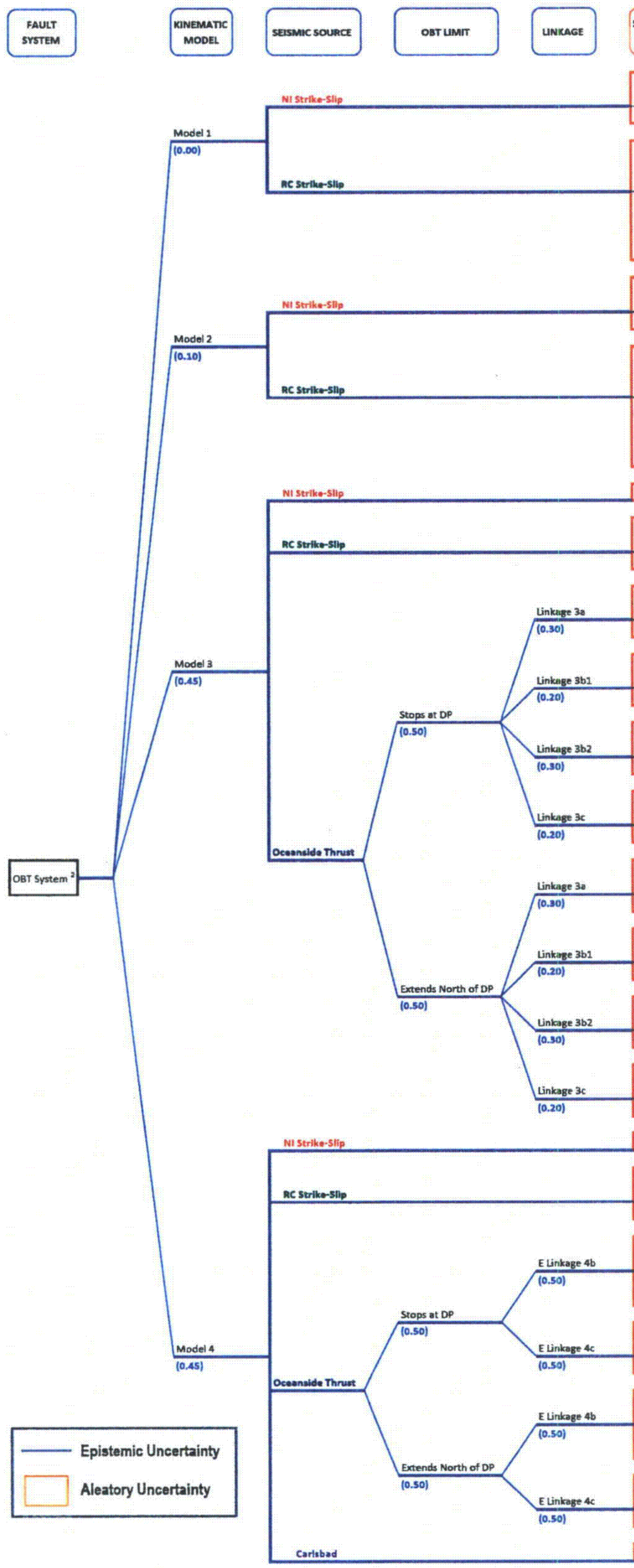
POTENTIAL RUPTURE SCENARIOS FOR BLIND THRUST AND RIGHT LATERAL STRIKE-SLIP SYSTEMS

FIGURE A3-4



Fault System	Kinematic Model	Seismic Source	OBT Limit	Linkage	Segmentation	Fault Segment Combination	Distribution of Segment Rupture	Long-Term Slip Rate (mm/yr)	Recurrence Model [1]	
OBT System [2]	Model 1 (0.00)	NI Strike-Slip			Single	G	25%	1.5+/-0.5	Characteristic	Trunc G-R
					Single	H	50%	1.0+/-0.5	Characteristic	Trunc G-R
					Multi	G + H	25%	1.0+/-0.5	Characteristic	Trunc G-R
		RC Strike-Slip			Single	I&J	10%	1.07+/-0.03	Characteristic	Trunc G-R
					Single	K	20%	1.07+/-0.03	Characteristic	Trunc G-R
					Single	L	20%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	I&J + K	10%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	K + L	20%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	I&J + L	10%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	I&J + K + L	10%	1.07+/-0.03	Characteristic	Trunc G-R
	Model 2 (0.10)	NI Strike-Slip			Single	G&wD	25%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	H	50%	1.0+/-0.5	Characteristic	Trunc G-R
					Multi	G&wD + H	25%	1.02+/-0.14	Characteristic	Trunc G-R
		RC Strike-Slip			Single	I&J&wE	10%	0.82+/-0.12	Characteristic	Trunc G-R
					Single	K	20%	1.07+/-0.03	Characteristic	Trunc G-R
					Single	L	20%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	I&J&wE + K	10%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	K + L	20%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	I&J&wE + L	10%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	I&J&wE + K + L	10%	0.82+/-0.12	Characteristic	Trunc G-R
	Model 3 (0.45)	NI Strike-Slip			Single	H	100%	1.0+/-0.5	Characteristic	Trunc G-R
		RC Strike-Slip			Single	K	33%	1.07+/-0.03	Characteristic	Trunc G-R
					Single	L	33%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	K + L	33%	1.07+/-0.03	Characteristic	Trunc G-R
		Oceanside Thrust	Stops at DP (0.50)	Linkage 3a (0.30)	Single	D	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D + E	33%	1.02+/-0.14	Characteristic	Trunc G-R
				Linkage 3b1 (0.20)	Single	D&fG	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&J	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D&fG + E&J	33%	1.74+/-0.2	Characteristic	Trunc G-R
				Linkage 3b2 (0.30)	Single	D	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&I	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D + E&I	33%	1.74+/ 0.2	Characteristic	Trunc G R
				Linkage 3c (0.20)	Single	D&fG	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&I&J	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D&fG + E&I&J	33%	1.74+/-0.2	Characteristic	Trunc G-R
			Extends North of DP (0.50)	Linkage 3a (0.30)	Single	D'	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D' + E	33%	1.02+/-0.14	Characteristic	Trunc G-R
				Linkage 3b1 (0.20)	Single	D'&fG	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&J	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D'&fG + E&J	33%	1.74+/-0.2	Characteristic	Trunc G-R
				Linkage 3b2 (0.30)	Single	D'	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&I	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D' + E&I	33%	1.74+/-0.2	Characteristic	Trunc G-R
				Linkage 3c (0.20)	Single	D'&fG	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&I&J	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D'&fG + E&I&J	33%	1.74+/-0.2	Characteristic	Trunc G-R
	Model 4 (0.45)	NI Strike-Slip			Single	H	100%	1.0+/-0.5	Characteristic	Trunc G-R
		RC Strike-Slip			Single	K	33%	1.07+/-0.03	Characteristic	Trunc G-R
					Single	L	33%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	K + L	33%	1.07+/-0.03	Characteristic	Trunc G-R
		Oceanside Thrust	Stops at DP (0.50)	E Linkage 4b (0.50)	Single	D	25%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E	25%	0.82+/-0.12	Characteristic	Trunc G-R
					Single	I	25%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	D + E	25%	1.02+/-0.14	Characteristic	Trunc G-R
				E Linkage 4c (0.50)	Single	D	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&I	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D + E&I	33%	1.74+/-0.2	Characteristic	Trunc G-R
			Extends North of DP (0.50)	E Linkage 4b (0.50)	Single	D'	25%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E	25%	0.82+/-0.12	Characteristic	Trunc G-R
					Single	I	25%	1.07+/-0.03	Characteristic	Trunc G-R
					Multi	D' + E	25%	1.02+/-0.14	Characteristic	Trunc G-R
				E Linkage 4c (0.50)	Single	D'	33%	1.02+/-0.14	Characteristic	Trunc G-R
					Single	E&I	33%	0.82+/-0.12	Characteristic	Trunc G-R
					Multi	D' + E&I	33%	1.74+/-0.2	Characteristic	Trunc G-R
		Carlsbad			Single	cb	100%	0.25+/-0.08	Characteristic	Trunc G-R

Notes:

[1] Recurrence based on 2/3 Characteristic Model and 1/3 Truncated Gutenberg-Richter Distribution

[2] See Appendix A, Attachment A-3 for details

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BLIND THRUST AND RIGHT LATERAL STRIKE-SLIP FAULT SYSTEM LOGIC TREE

FIGURE A3-5

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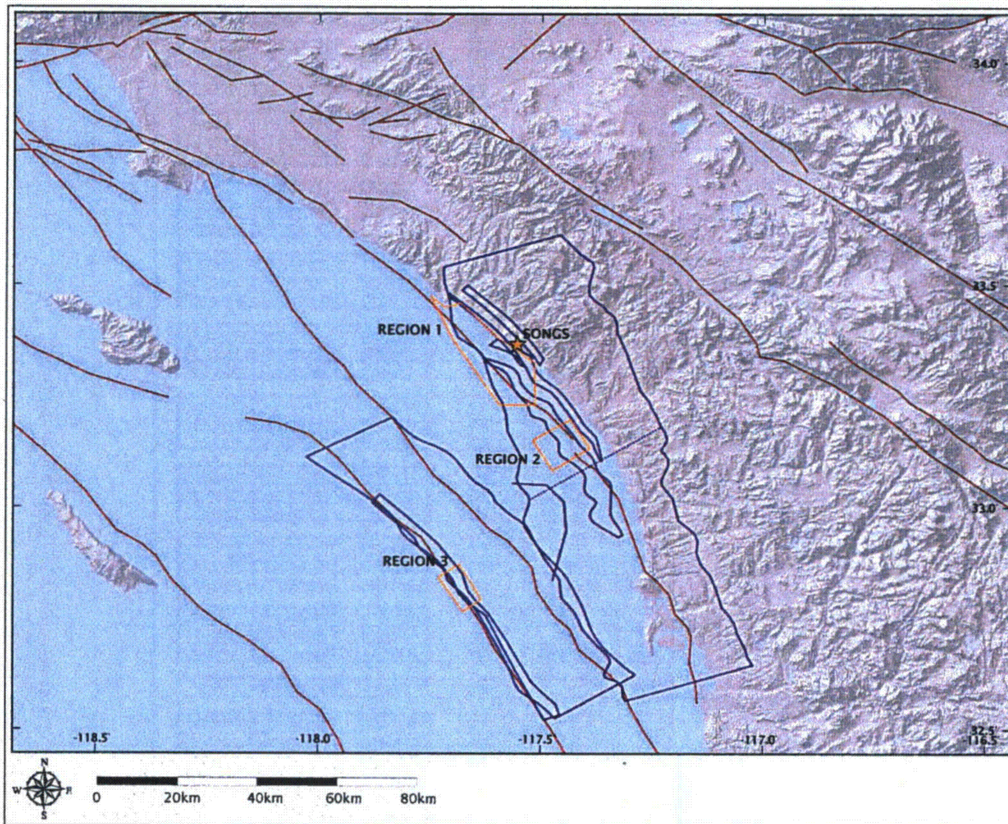
SEISMIC HAZARD ASSESSMENT PROGRAM



Legend

- SONGS Facility Location
- Fault Systems from Rivero (2004)
- Fault Traces from USGS (2009)
- Areas Recommended for Future Study

Region	Approx. Area
Region 1	250 km^2
Region 2	90 km^2
Region 3	50 km^2

Notes:

Base map is shaded relief of southern California based on SRTM model prepared by ESRI, 2009.

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SEISMIC HAZARD ASSESSMENT PROGRAM

LOCATIONS FOR RECOMMENDED FUTURE STUDIES

FIGURE A3-6

APPENDIX B
2010 PSHA GROUND MOTION CHARACTERIZATION

APPENDIX B OUTLINE

APPENDIX B
2010 PSHA GROUND MOTION CHARACTERIZATION

B1.0 INTRODUCTION

This Appendix provides further discussions on selected PSHA-related issues addressed in the main report. The selected issues consist of QA/QC work done on the PSHA computer program HAZ4.2 (Abrahamson, 2010); characterization of the site shear wave velocity parameters used in the attenuation relationships; epistemic uncertainty associated with the attenuation relationships used; and recurrence relationships for the hypothesized OBT source.

B2.0 QA/QC OF HAZ4.2 PSHA COMPUTER PROGRAM

The PSHA computer program HAZ4.2, developed by Dr. Norman Abrahamson (2010) as the newest version of his PSHA program, was selected for use in the 2010 PSHA. This latest version enabled SHAP to implement the NSHM 2009 (USGS, 2009, PC) seismic source model and adopt the UCERF 2 (WGCEP, 2008) time independent model for conducting PSHA. However, because HAZ4.2 had not yet gone through a QA/QC process, SHAP, guided by Dr. Norman Abrahamson, followed the PSHA Validation Project methodology described in Thomas et al. (2010) to initiate this QA/QC process. The process was completed for the elements of HAZ4.2 pertinent to this study, but not others. The resulting QA/QC'd portion of the HAZ4.2 computer program will be considered an interim version of HAZ4.2 on the 2010 PSHA. The actual process in completing the QA/QC'd portion of HAZ4.2 involved interactions of SHAP with Dr. Nicholas Gregor who works with Dr. Norman Abrahamson in developing the program. SHAP and Dr. Nicholas Gregor completed a series of computer runs followed by identifications and modification resolutions on various aspects of the computer program.

The purpose of the PSHA Validation Project (Thomas et al., 2010) was to develop a consistent method for testing several aspects of the PSHA calculation process for various, widely-used PSHA computer programs in the engineering community. The validation process consisted of test cases using strike-slip, reverse, and areal sources along with various site locations as illustrated on Figure B-1. Figure B-1 also shows the sites used in the validation. The test cases were designed to address calculation of site distance, rate, ground motion attenuation, hanging wall effects, earthquake recurrence, ground motion variability, and rupture area variability against hand-calculations whenever available. The test case results for each computer program were validated by comparing them to Pacific Earthquake Engineering Research (PEER) reported results by Thomas et al. (2010) for each test case.

SHAP compared the HAZ4.2 results for all test cases against the PEER reported results from Thomas et al. (2010). Figures B-2 and B-3 compare the HAZ4.2 results with the PEER reported results for two different cases as example results. As shown on Figures B-2 and B-3, the HAZ4.2 results match with the PEER reported results from Thomas et al. (2010). The comparisons of results shown on Figures B-2 and B-3 are representative of the remaining 104 cases considered. The final results for all test cases of the QA/QC process, when eventually completed, will be presented in a report titled "QA/QC of HAZ4.2 PSHA Computer Program."

B3.0 SHEAR WAVE VELOCITY PARAMETERS USED IN NGA RELATIONSHIPS

Table B-1 shows the attenuation relationships from the NGA models used in the PSHA. These attenuation relationships are called the NGA relationships herein and consist of the following:

- Abrahamson and Silva (2008)
- Boore and Atkinson (2008)
- Campbell and Bozorgnia (2008)
- Chiou and Youngs (2008)
- Idriss (2008)

Table B-1 also summarizes the estimated shear-wave velocity parameters for SONGS used in the NGA relationships, including 1) the average shear-wave velocity from the ground surface to a depth of 30 m (V_{S30}), 2) the approximate depth to 1 km/s shear-wave velocity material ($Z_{1.0}$), and 3) the approximate depth to 2.5 km/s shear-wave velocity material ($Z_{2.5}$). These shear wave velocity parameters, not all of them used by all five relationships listed above, were based on relevant data compiled from past reports documenting previous site investigations. Figures B-4 and B-5 present compilations of the site seismic velocity data from the ground surface to a depth of 30 m and 4,000 m, respectively. These figures show both shear- and pressure-wave data that was either directly measured in the site vicinity (colored solid lines) or was estimated based on other data (colored dashed lines). Also, a generalized stratigraphic column showing the geologic units is presented between the shear- and pressure-wave graphs on Figures B-4 and B-5. This geologic interpretation is based on data presented in Dames & Moore (1970) and SCE (2001).

As shown on Figures B-4 and B-5, the pressure-wave velocities at the site were directly measured from 1) a surface seismic velocity survey by Dames & Moore (1970), 2) an acoustic velocity survey of borehole B-1 by Dames & Moore (1970), 3) a downhole seismic velocity survey by Weston Geophysical (1971), 4) an offshore seismic reflection survey by Western Geophysical (1972), and 5) geophysical data compiled by Dames & Moore (1970) to the base of the San Onofre Breccia (Tso) or to a depth of approximately 1,525 m (5,000 ft). Below the base of the San Onofre Breccia, the pressure-wave data was estimated by Dames & Moore (1970) based on measurements performed within the deeper rock units in the region by others.

As shown on Figures B-4 and B-5, the shear-wave velocities at the site were directly measured from 1) a surface seismic velocity survey by Dames & Moore (1970), 2) a downhole seismic velocity survey by Weston Geophysical (1971), 3) Rayleigh wave tests by Woodward-McNeill (1974), and 4) geophysical data compiled by Dames & Moore (1970) to the base of the Monterey Formation Tm (see Figure B-5) or to a depth of approximately 760 m (2,500 ft).

Shear-wave velocities at the site were also estimated based on pressure-wave velocities, Poisson's ratio, and shear modulus relationships. As shown on Figures B-4 and B-5, shear-wave velocities below the base of the Monterey Formation were computed by Dames & Moore (1970) from pressure-wave velocities and estimates of the Poisson's ratio measured in similar materials. Estimates of the shear-wave velocity were also calculated from the acoustic velocity log within B1 shown on Figures B-4 and B-5 (Dames & Moore, 1970) and the offshore seismic pressure-wave data (Western Geophysical, 1972) using the

Poisson's ratio values presented in Dames & Moore (1970). Lastly, shear-wave velocities estimates were calculated based on shear modulus relationships presented in Woodward-McNeill (1972). These estimates were calculated for the San Mateo Formation to a depth of 285 m (935 ft).

The San Mateo Formation sandstone comprises the first 30 m of geologic material beneath SONGS. As shown on Figure B-4, the shear-wave velocities measured or estimated within the first 30 m below the site are relatively similar to each other with the widest spread in values in the near-surface between approximately 0 and 12 m. The V_{s30} values based on Dames & Moore (1970) data (solid yellow and red lines on Figure B-4) and estimated based on offshore data by Western Geophysical (1972) (dashed green line on Figure B-4) are approximately 670 m/s and 730 m/s, respectively. These V_{s30} values were based on widely spaced survey data and pressure-wave velocity measurements that resulted in poor resolution of the near-surface shear-wave velocity values. Investigations resulting in a higher resolution of near-surface shear-wave velocities were performed by Weston (1971) (solid magenta line on Figure B-4) and Woodward-McNeill (1974) (solid purple line on Figure B-4). The V_{s30} based on the Weston (1971) data is approximately 500 m/s. The V_{s30} value was also calculated by combining the Woodward-McNeill (1974) data (solid purple line), which had a maximum exploration depth of about 4.5 m, with the shear-wave velocity estimated based on the San Mateo Formation's shear modulus relationship developed by Woodward-McNeill (1972) (dashed cyan line on Figure B-4). As shown on Figure B-4, this combined V_{s30} is about 500 m/s, which is the same as the V_{s30} based on the Weston (1971) data. Since the Weston and Woodward-McNeill data provided the best resolution of shear-wave velocities within the first 30 m of the San Mateo Formation, the V_{s30} within the San Mateo Formation at the site is estimated to be 500 m/s for the NGA relationships in Table B-1.

As shown on Figure B-5, the estimated $Z_{1.0}$ varies depending on the source of the shear-wave velocity data. The upper bound of $Z_{1.0}$ is approximately 135 m and is based on the San Mateo Formation shear modulus relationship developed by Woodward-McNeill (1972) (dashed cyan line on Figure B-5). The $Z_{1.0}$ based on the Dames and Moore (1970) data (solid red line on Figure B-5) and Western Geophysical (1972) data (dashed green line on Figure B-5) is approximately 610 m and 305 m, respectively. This puts the $Z_{1.0}$ at the top of the Monterey Formation, which varies between the two sources. It is noted that the top of the Monterey Formation at the site, as shown on the geology log on Figure B-5, is based on the Western Geophysical (1972) offshore seismic data presented in SCE (2001), and includes the latest geologic interpretation. This latest geologic interpretation together with the idea that the $Z_{1.0}$ depth occurs at the top of the Monterey Formation leads to a $Z_{1.0}$ depth of approximately 305 m, which was used in the NGA relationships in Table B-1. This value is similar to the average of all $Z_{1.0}$ sources, which is approximately 350 m.

Dames and Moore (1970) provides the only site-specific shear-wave data below the base of the Monterey Formation (dashed red lines on Figure B-5). As shown on Figure B-5, the $Z_{2.5}$ is estimated to occur at approximately 3,350 m, which corresponds to the approximate top of the crystalline basement igneous and metamorphic rocks.

B4.0 GROUND MOTION PREDICTION EQUATION EPISTEMIC UNCERTAINTY

The attenuation relationships associated with the NGA work are often referred to as the GMPE. In using attenuation relationships, their epistemic uncertainty should be considered. In the past, this epistemic uncertainty was often accommodated by using multiple attenuation relationships. However, given the coordinated process used to develop the NGA relationships, it should not be adequate to address this epistemic uncertainty by just using multiple NGA relationships. An epistemic GMPE uncertainty in addition to the use of five NGA relationships was reflected in the PSHA herein as described below.

The additional epistemic uncertainty follows USGS (2008) as summarized below:

The USGS applies the epistemic uncertainty dgnd symmetrically (USGS, 2008) so that the weights for (ln(gnd)+dgnd) and (ln(gnd)-dgnd) are the same at 0.185 and the unmodified ln(gnd) has a weight of 0.63. Here, ln(gnd) stands for the natural logarithm of the median peak or spectral acceleration, "gnd", for a given attenuation relationship. The term "dgnd" stands for the median or spectral acceleration uncertainty for any given attenuation relationship.

Due to the limitations of the data (particularly for large earthquakes) used in developing the NGA relationships and the considerable interactions that took place among the NGA modelers (USGS, 2008), NGA modelers suggested that the NGA relationships should also incorporate epistemic uncertainty (beyond using multiple relationships). Following the NGA modelers' suggestion, the USGS partitioned the source space into nine (9) bins determined by three partitions in the distance space (0 to 10 km, 10 to 30 km, and larger than 30 km) and three partitions in the magnitude space (5 to 6, 6 to 7, and larger than 7) as shown in Table B-2. However, of all the attenuation relationships considered by the USGS, only Campbell and Bozorgnia (2008) and Chiou and Youngs (2008) provided sufficient information to estimate the epistemic uncertainty within the nine bins considered. Based on an average epistemic uncertainty, Table B-2 shows the resulting epistemic uncertainty within each of the 9 bins considered by the USGS (2008).

As in the USGS evaluation, the space was divided into 9 bins (3 ranges in the magnitude space and 3 ranges in the distance space). Within each bin, an average value of the range was used to compute the peak or spectral accelerations for all 5 attenuation relationships considered. For example, in the case of the magnitude range 6 to 7, and distance the range 0 to 10 km, an average magnitude value of 6.5 and an average rupture distance of 5 km was used to compute the spectral ordinates from all 5 attenuation relationships. Figures B-6 and B-7 show the computed spectral ordinates for strike-slip and reverse faulting mechanism, respectively. Next, the ratio of the maximum to minimum calculated spectral accelerations was computed for each frequency. Figure B-8 shows the resulting ratios for each of the two styles of faulting mechanism considered, as well as their average values within the range of frequencies of interest. In general, the average ratio for the reverse faulting mechanism tends to be larger than that of the strike-slip faulting mechanism. In the present evaluation, average ratios obtained from the reverse faulting mechanism were used.

The epistemic uncertainty from the attenuation relationships can be compared to the epistemic uncertainty values provided by the USGS by noting that the minimum and maximum spectral accelerations are provided by (ln(gnd)-dgnd) and (ln(gnd)+dgnd), respectively. Therefore, in the USGS case, the ratio of maximum ("max") to minimum ("min") response spectra is provided by:

$$Sa_{Max,USGS}/Sa_{Min,USGS} = \exp[\ln(gnd) + dgnd] / \exp[\ln(gnd) - dgnd]$$

$$Sa_{Max,USGS}/Sa_{Min,USGS} = \exp(2 \times dgnd)$$

where $Sa_{Max,USGS}/Sa_{Min,USGS}$ is the ratio of the maximum and minimum USGS spectral acceleration. Conversely, for a given average ratio value, the corresponding epistemic dgnd term can also be computed as follows:

$$dgnd = \ln(Sa_{Max,USGS}/Sa_{Min,USGS})/2$$

In the example case cited above, the comparison of the USGS epistemic uncertainty ratio and the attenuation relationship epistemic uncertainty is shown on Figure B-9. The computed dgnd term obtained from the attenuation relationship epistemic uncertainty is provided in Table B-3.

A comparison of the dgnd terms provided by the USGS listed in Table B-2 and the attenuation relationship epistemic uncertainty listed in Table B-3 is also shown in graphical form on Figure B-10.

The results from the use of the five attenuation relationships already reflect some epistemic uncertainty from the attenuation relationships. In order to account for the "full" GMPE epistemic uncertainty due to the lack of data, the difference between the two dgnd values for each of the nine bins above needs to be considered. The final epistemic uncertainty included in the current study is provided in Table B-4.

In this study, the events controlling the shaking condition at the site were mainly magnitude 6 to 7 events with a distance range of less than 10 km. Therefore, the epistemic uncertainty for this magnitude range and distance range is the only one that was used for all five attenuation relationships considered in the PSHA evaluation.

B5.0 RECURRENCE RELATIONSHIPS

The recurrence relationships used for the NI/RC Fault Zone source were based on the time-independent part of the UCERF 2 and followed the UCERF 2 methodology (WGCEP, 2008). Following this methodology, a characteristic recurrence relationship (Youngs and Coppersmith, 1985) was assigned a weight of 2/3, and a truncated exponential relationship (Youngs and Coppersmith, 1985) was assigned a weight of 1/3. For the hypothesized OBT source, which was not based on the UCERF 2, appropriate recurrence relationships to be used were guided in part by available historic seismicity data.

Figure B-11 shows 1) the limited observed historic main shock seismicity evaluated for completeness in the area of SONGS and 2) a region generally within 10 km of the hypothesized OBT used in the evaluation of historic seismicity data for the hypothesized OBT source. The historic seismicity catalog and general methodologies used to process this catalog are from UCERF2 (WGCEP, 2008). Figure B-12 shows the hypothesized OBT earthquake recurrence based on the observed historic earthquakes within the hypothesized OBT region (five total, as shown on Figure B-11). The historic seismicity model shown on Figure B-12 includes: 1) the cumulative annual frequency of occurrence of various magnitude or greater observed earthquakes (shown as open circles) and 2) the upper and lower standard deviation recurrence bounds based on Weichert (1980) (shown as vertical bars). Figure B-12 also shows the earthquake recurrence relationship developed using the seismic source parameters for the hypothesized OBT source (Section 2.0 and Appendix B) and assuming only the characteristic recurrence model by Youngs and Coppersmith (1985). As shown on Figure B-12, the use of only the characteristic recurrence relationship to represent the hypothesized OBT source results in the recurrence relationship that is reasonably consistent with the historic seismicity in the hypothesized OBT region. On the basis of the results shown on Figure B-12, only the characteristic recurrence relationship was used to represent the hypothesized OBT source.

TABLE B-1
NGA Relationships and Shear-wave Velocity Parameters

NGA	Epistemic Weight	Shear-Wave Velocity Parameters†		
		V_{s30}*	$Z_{1.0}$**	$Z_{2.5}$***
Abrahamson and Silva (2008)	0.20	500-m/s	0.31-km	3.35-km
Boore and Atkinson (2008)	0.20			
Campbell and Bozorgnia (2008)	0.20			
Chiou and Youngs (2008)	0.20			
Idriss (2008)	0.20			

†Used as needed in each NGA relationship
*V_{s30} = the average shear wave velocity from the ground surface to a depth of 30-m
**$Z_{1.0}$ = the approximate depth to 1.0 km/s shear wave velocity material
***$Z_{2.5}$ = the approximate depth to 2.5 km/s shear wave velocity material

TABLE B-2
Epistemic Uncertainty in the GMPE (natural log term)

Magnitude Range	Rupture Distance Range	Average *dgnd* Term
5 to 6	0 to 10km	±0.375
	10 to 30km	0.21
	≥30km	0.245
6 to 7	0 to 10km	0.23
	10 to 30km	0.225
	≥30km	0.23
≥7	0 to 10km	0.40
	10 to 30km	0.36
	≥30km	0.31

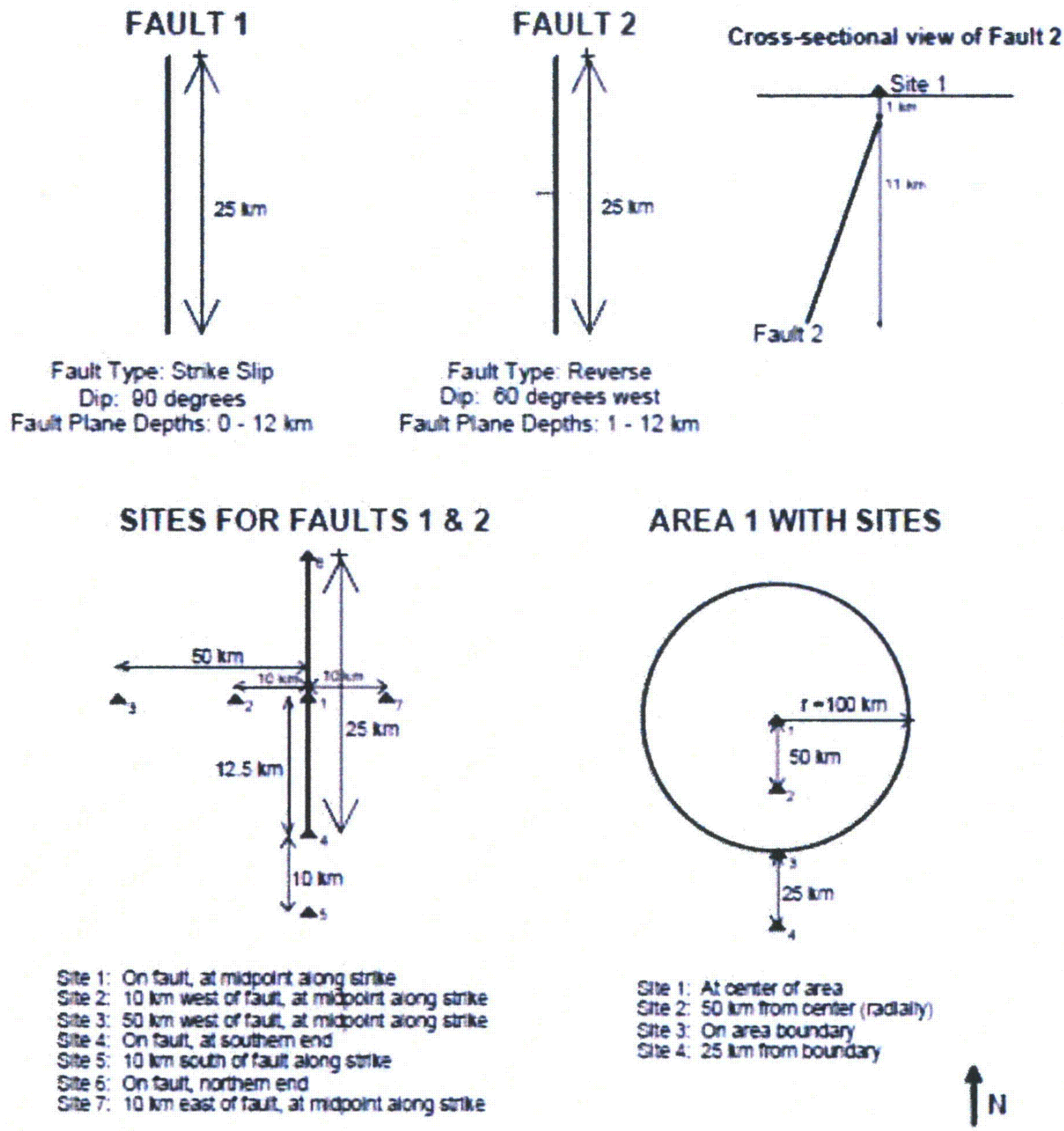
TABLE B-3
Epistemic Uncertainty in the Attenuation Relationships (natural log term)

Magnitude Range	Rupture Distance Range	Average *dgnd* Term
5 to 6	0 to 10km	±0.285
	10 to 30km	0.252
	≥30km	0.293
6 to 7	0 to 10km	0.157
	10 to 30km	0.15
	≥30km	0.208
≥7	0 to 10km	0.17
	10 to 30km	0.154
	≥30km	0.147

TABLE B-4
Epistemic Uncertainty (natural log term) Used in the Current Study

Magnitude Range	Rupture Distance Range	Average *dgnd* Term
5 to 6	0 to 10km	±0.090
	10 to 30km	0.0*
	≥30km	0.0*
6 to 7	0 to 10km	0.073
	10 to 30km	0.075
	≥30km	0.022
≥7	0 to 10km	0.230
	10 to 30km	0.206
	≥30km	0.163

* signifies that when the dgnd value from the attenuation relationships exceeds the USGS dgnd value, an epistemic uncertainty value of 0.0 was conservatively used.



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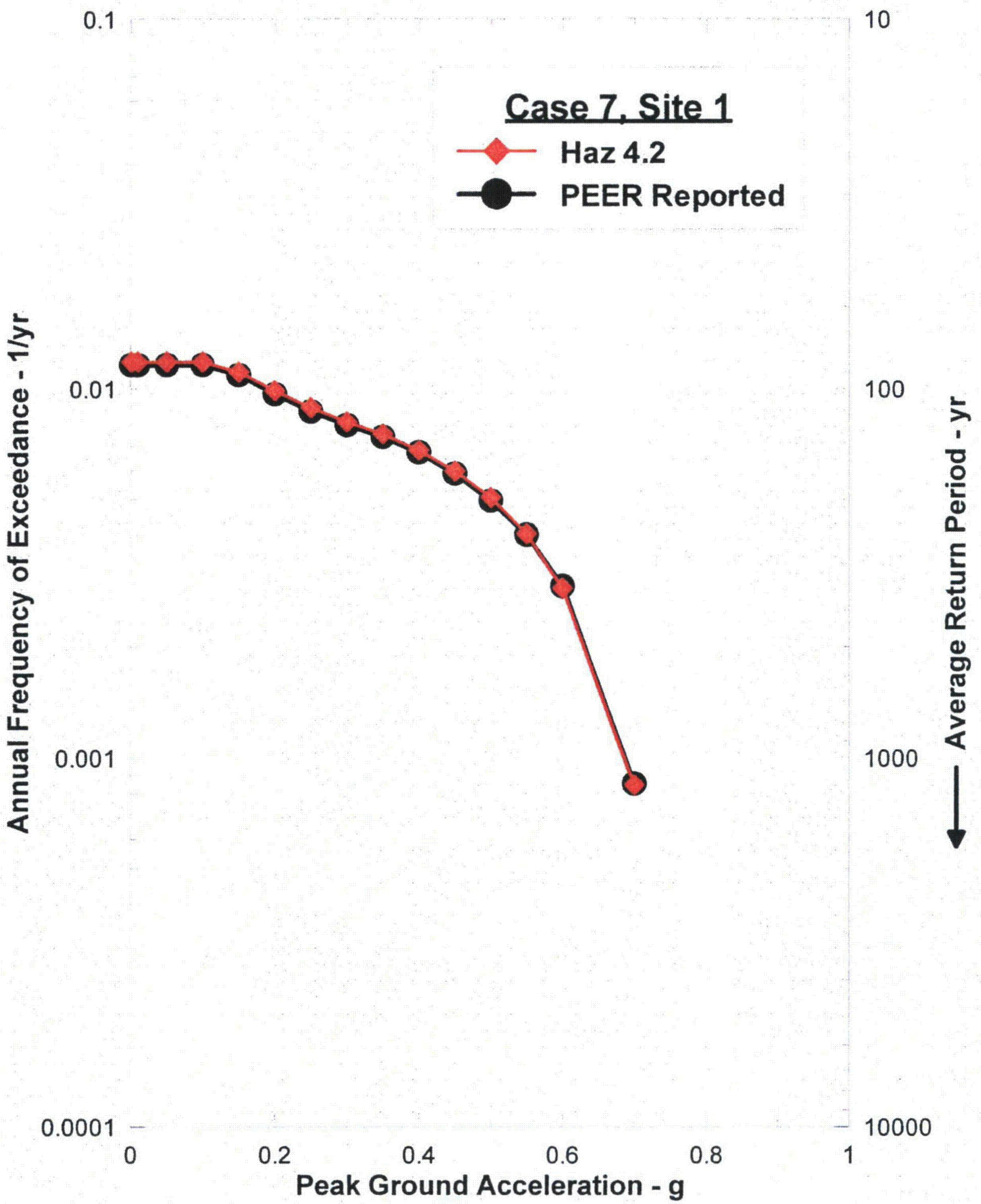
QA/QC OF HAZ4.2 -
FAULT AND SITE GEOMETRY FOR TEST CASES

FIGURE B-1

SAN ONOFRE NUCLEAR GENERATING STATION

SEISMIC HAZARD ASSESSMENT PROGRAM



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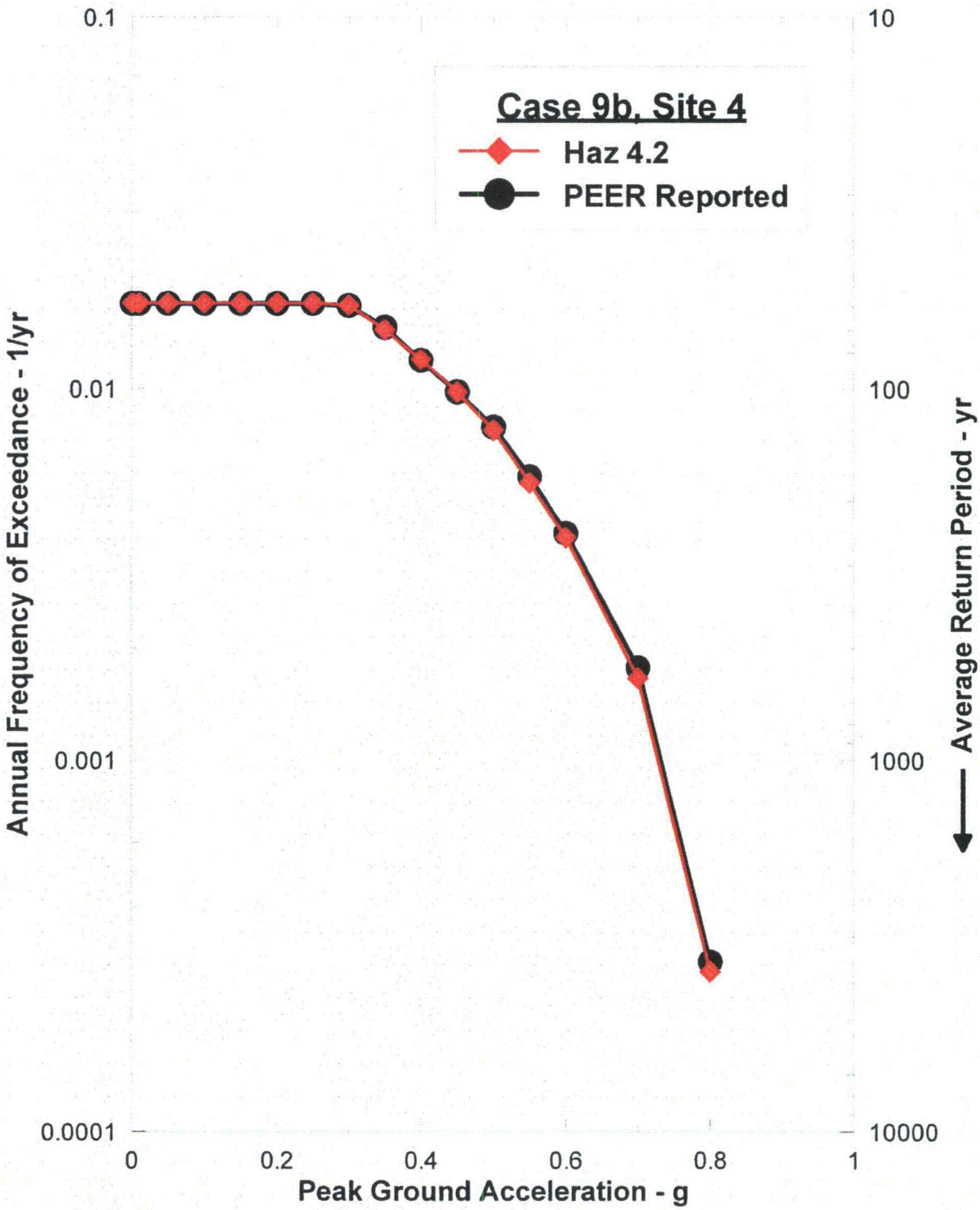
QA/QC OF HAZ4.2 -
TEST CASE 7, SITE 1

FIGURE
B-2

SAN ONOFRE NUCLEAR GENERATING STATION

SEISMIC HAZARD ASSESSMENT PROGRAM



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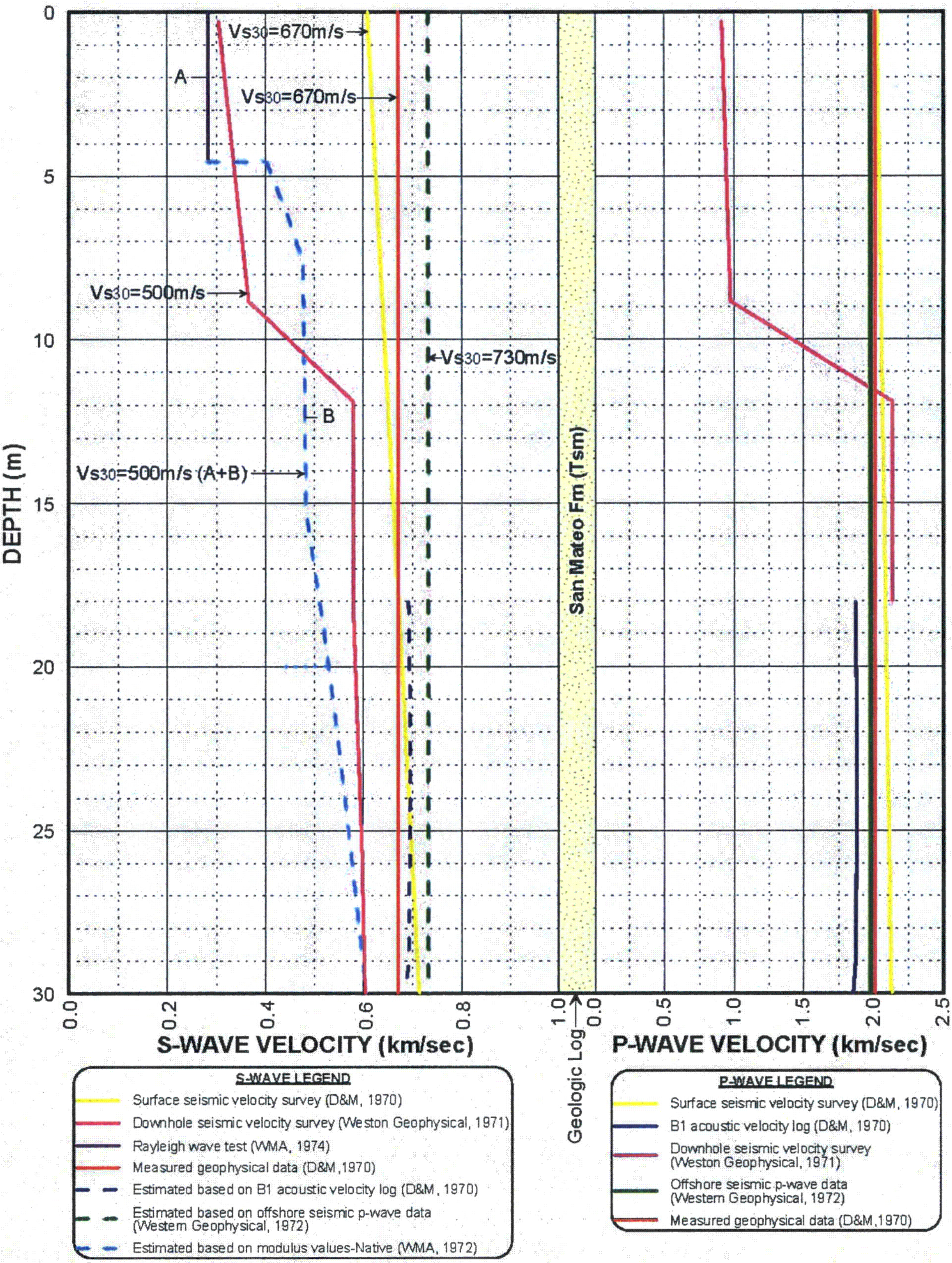
QA/QC OF HAZ4.2 -
TEST CASE 9b, SITE 4

FIGURE
B-3

SAN ONOFRE NUCLEAR GENERATING STATION

SEISMIC HAZARD ASSESSMENT PROGRAM



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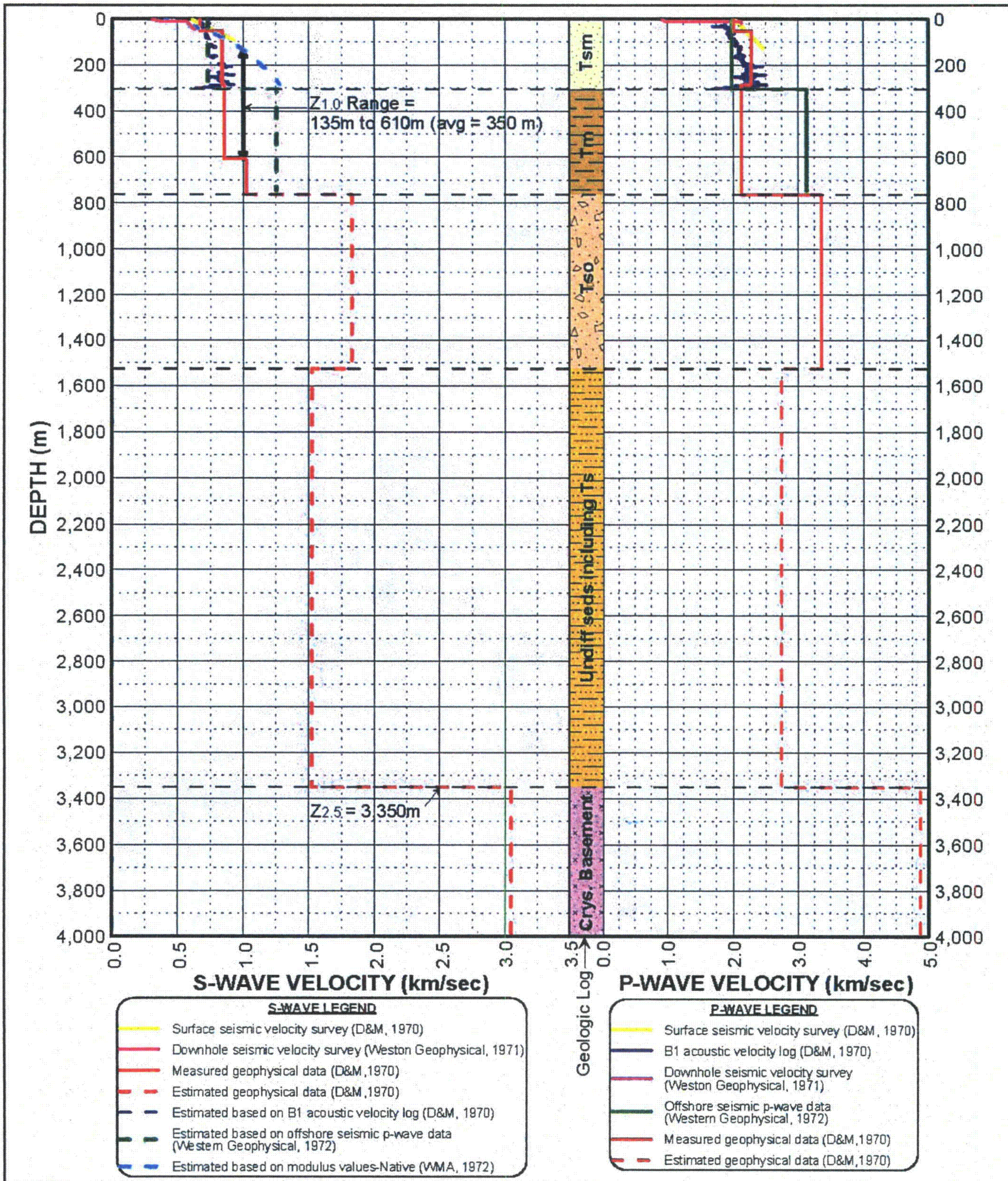
SHEAR- WAVE AND PRESSURE- WAVE VELOCITY SUMMARY (0 to 30 m)

FIGURE B-4

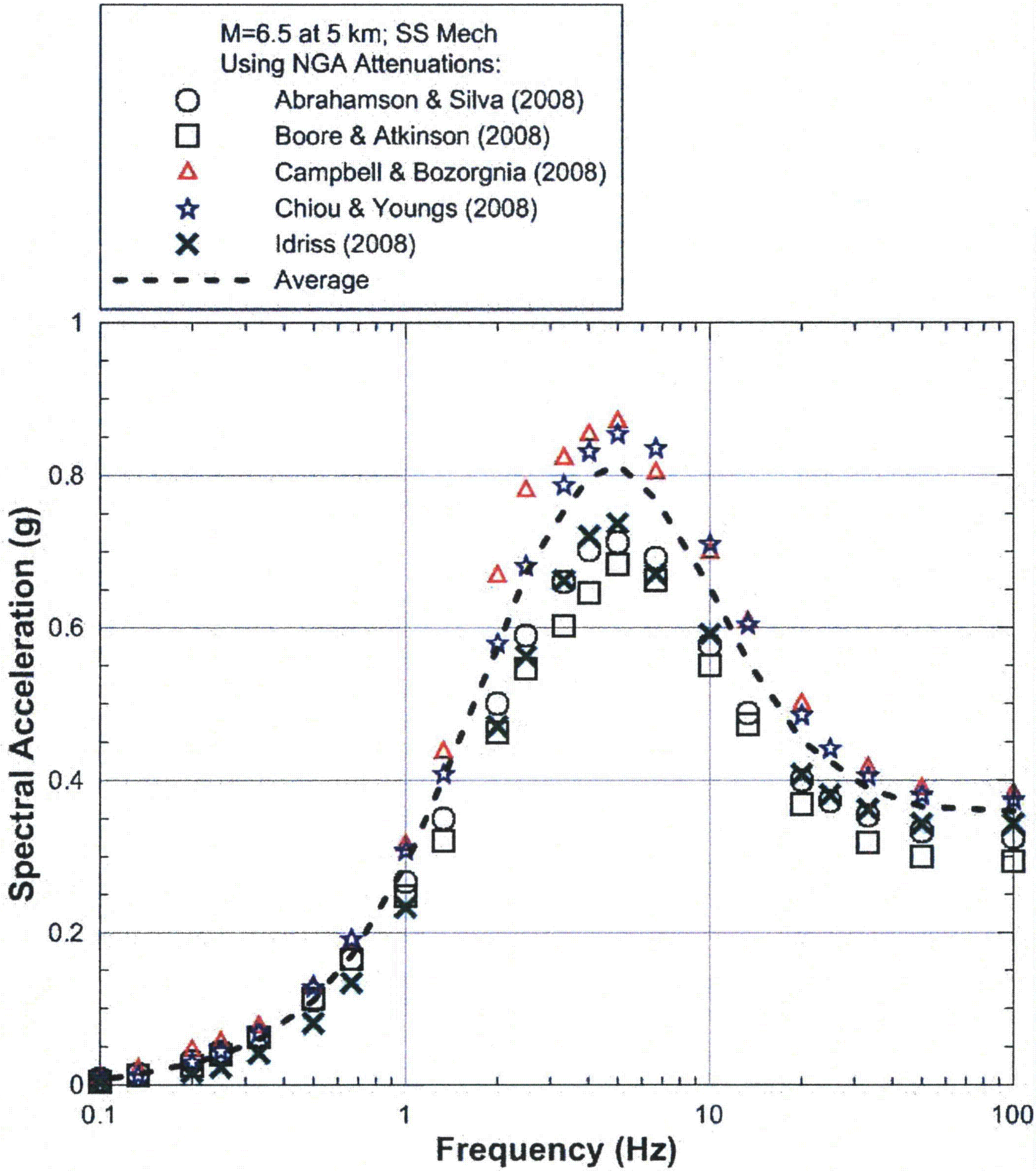
SAN ONOFRE NUCLEAR GENERATING STATION

SEISMIC HAZARD ASSESSMENT PROGRAM



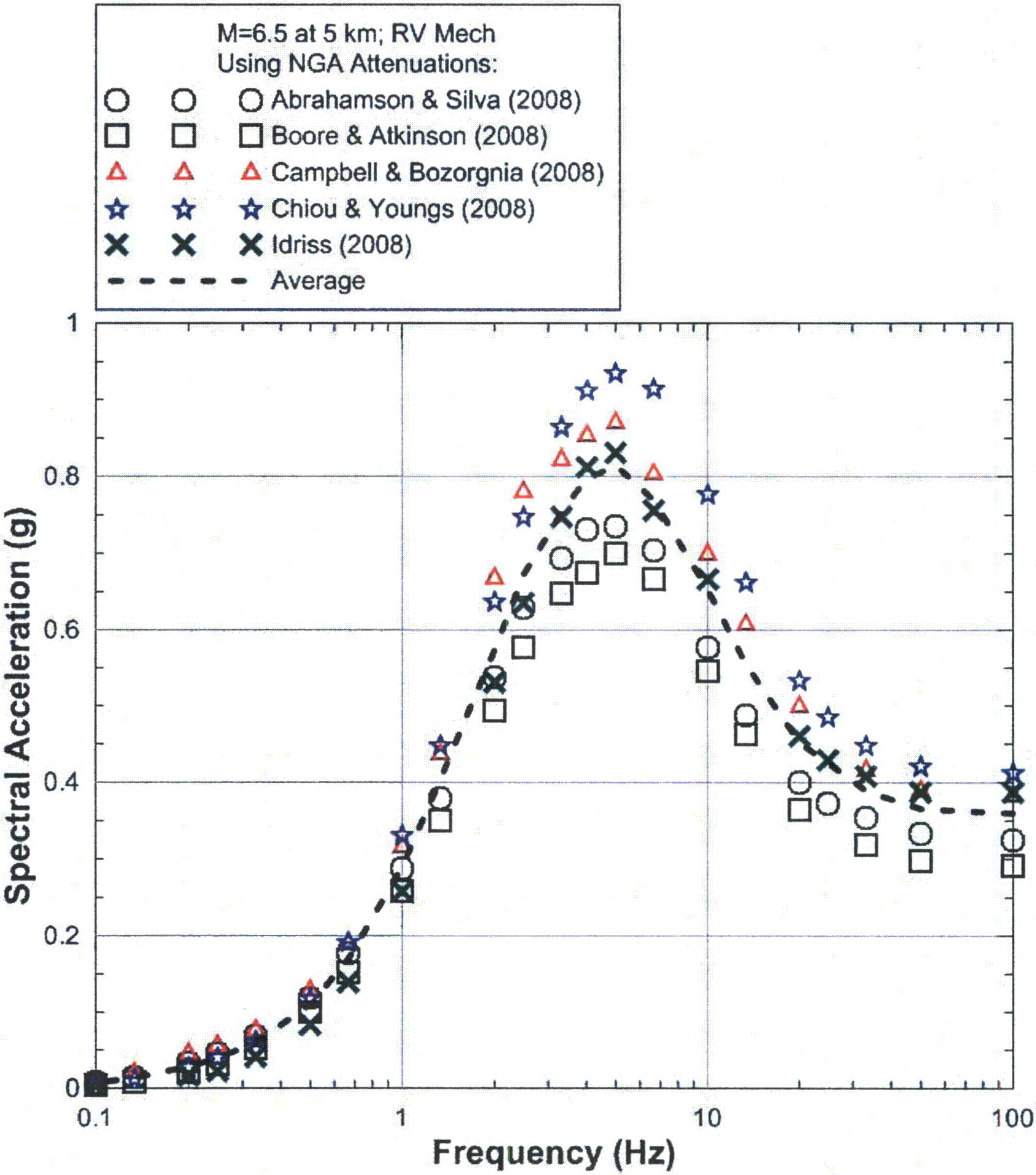
NOTE: Geology based on D&M (1970) and SCE (2001).
Tsm= San Mateo Fm.; Tso=San Onofre Breccia; Ts=Santiago Fm.

GeoPentech Geotechnical & Geoscience Consultants	SHEAR- WAVE AND PRESSURE- WAVE VELOCITY SUMMARY (0 to 4,000 m)	FIGURE B-5
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



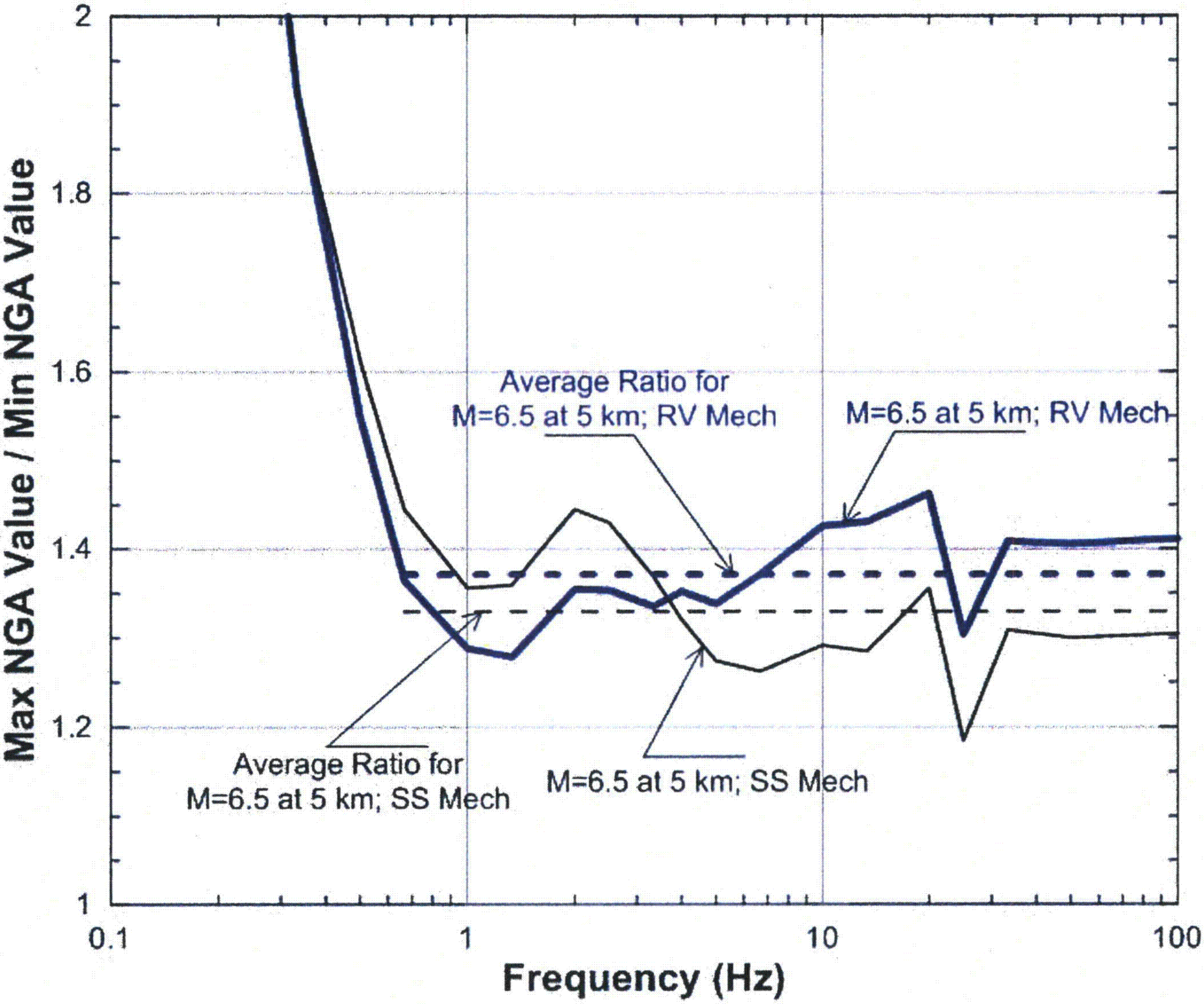
NOTE: Mw=6.5 at 5 km for strike-slip faulting mechanism

GeoPentech	RESPONSE SPECTRA FOR THE 5 NGA ATTENUATION RELATIONSHIPS USED	FIGURE B-6
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



NOTE: Mw=6.5 at 5 km for reverse faulting mechanism

GeoPentech	RESPONSE SPECTRA FOR THE 5 NGA ATTENUATION RELATIONSHIPS USED	FIGURE B-7
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



NOTE: Mw=6.5 at 5 km for strike-slip and reverse faulting mechanism

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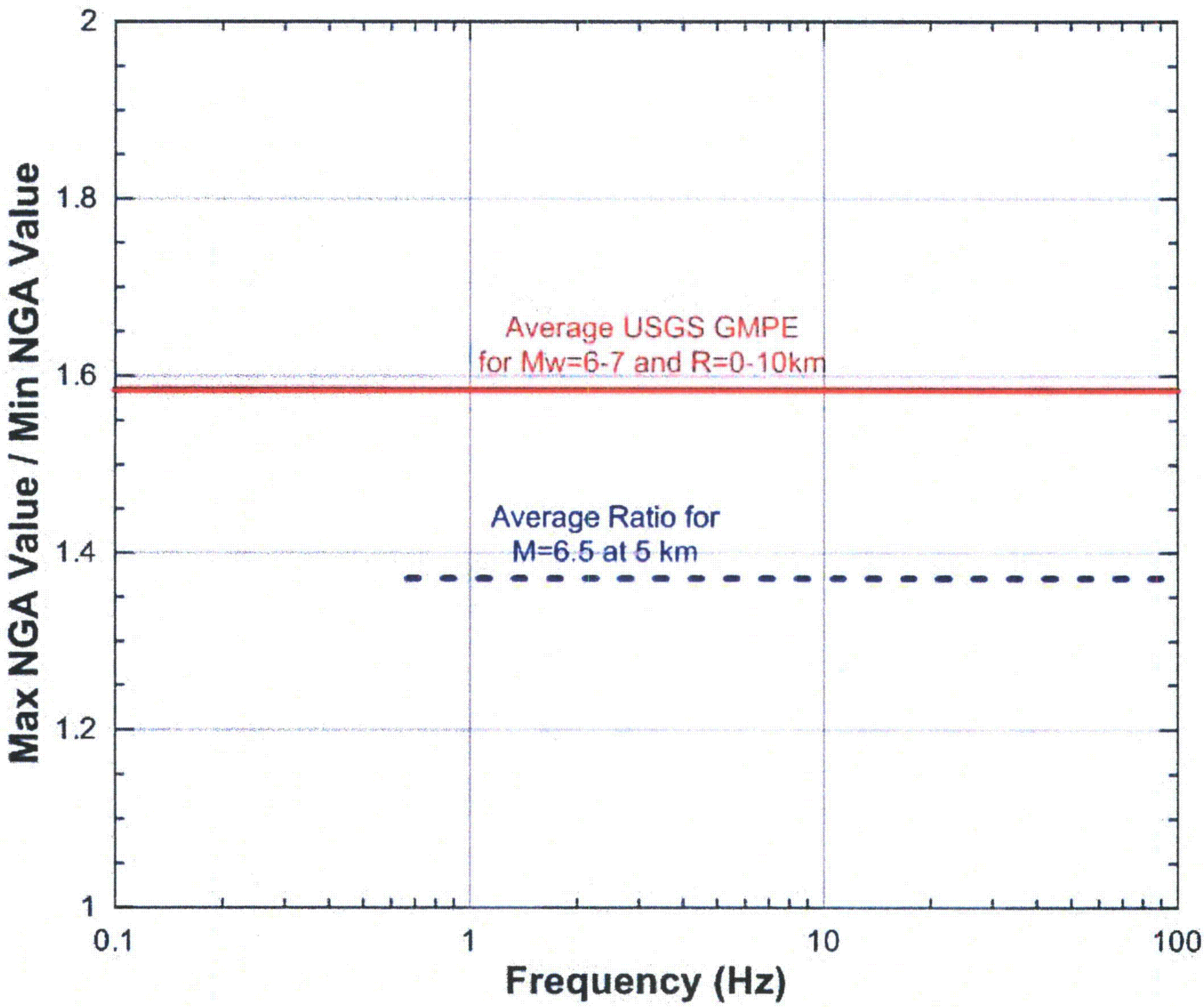
RATIOS OF MAXIMUM TO MINIMUM SPECTRAL ACCELERATIONS

FIGURE B-8

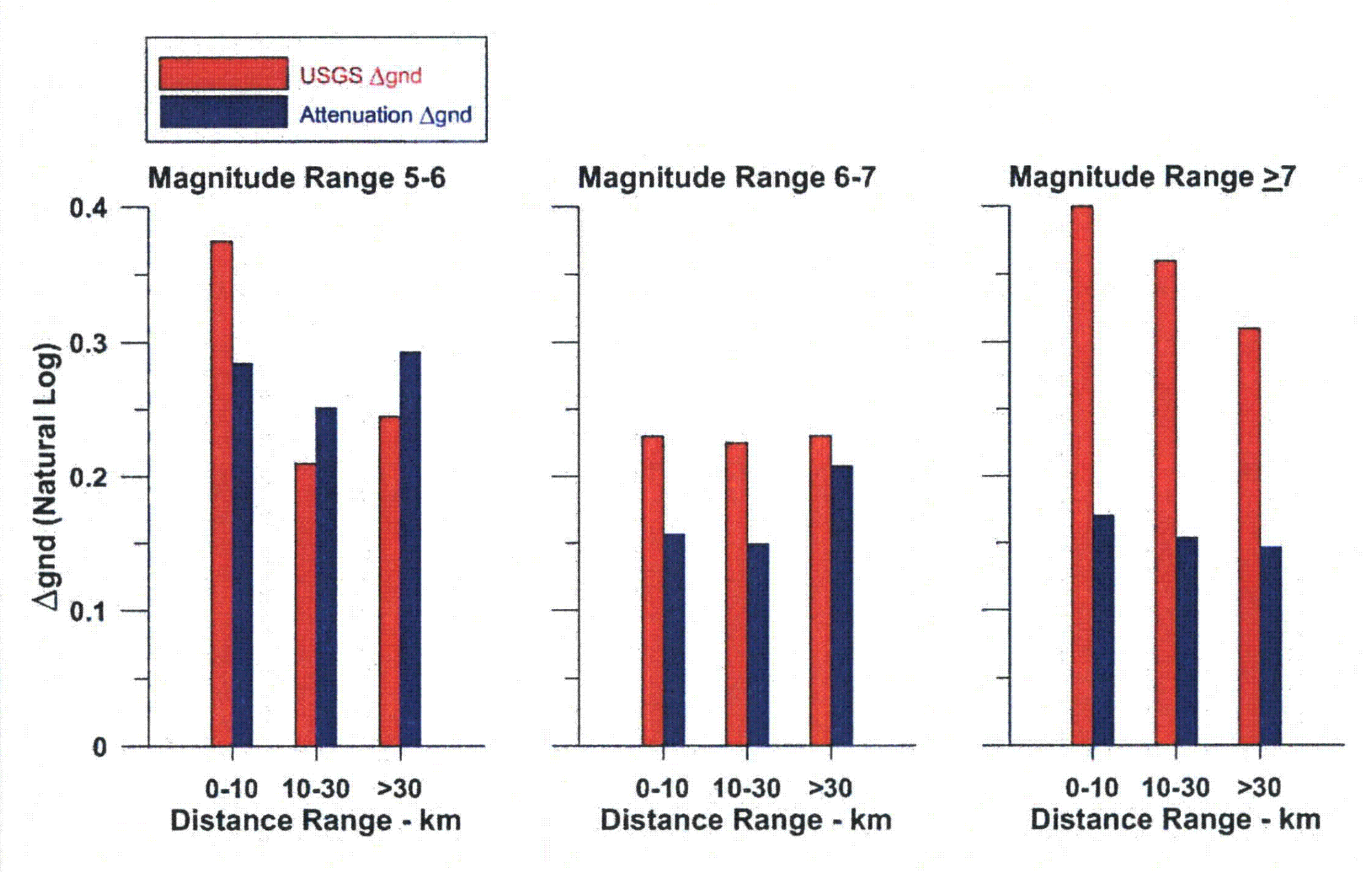
SAN ONOFRE NUCLEAR GENERATING STATION

SEISMIC HAZARD ASSESSMENT PROGRAM



NOTE: Mw=6-7, R=0-10 km

GeoPentech	COMPARISON OF USGS EPISTEMIC UNCERTAINTY AND ATTENUATION RELATIONSHIP EPISTEMIC UNCERTAINTY	FIGURE B-9
	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	



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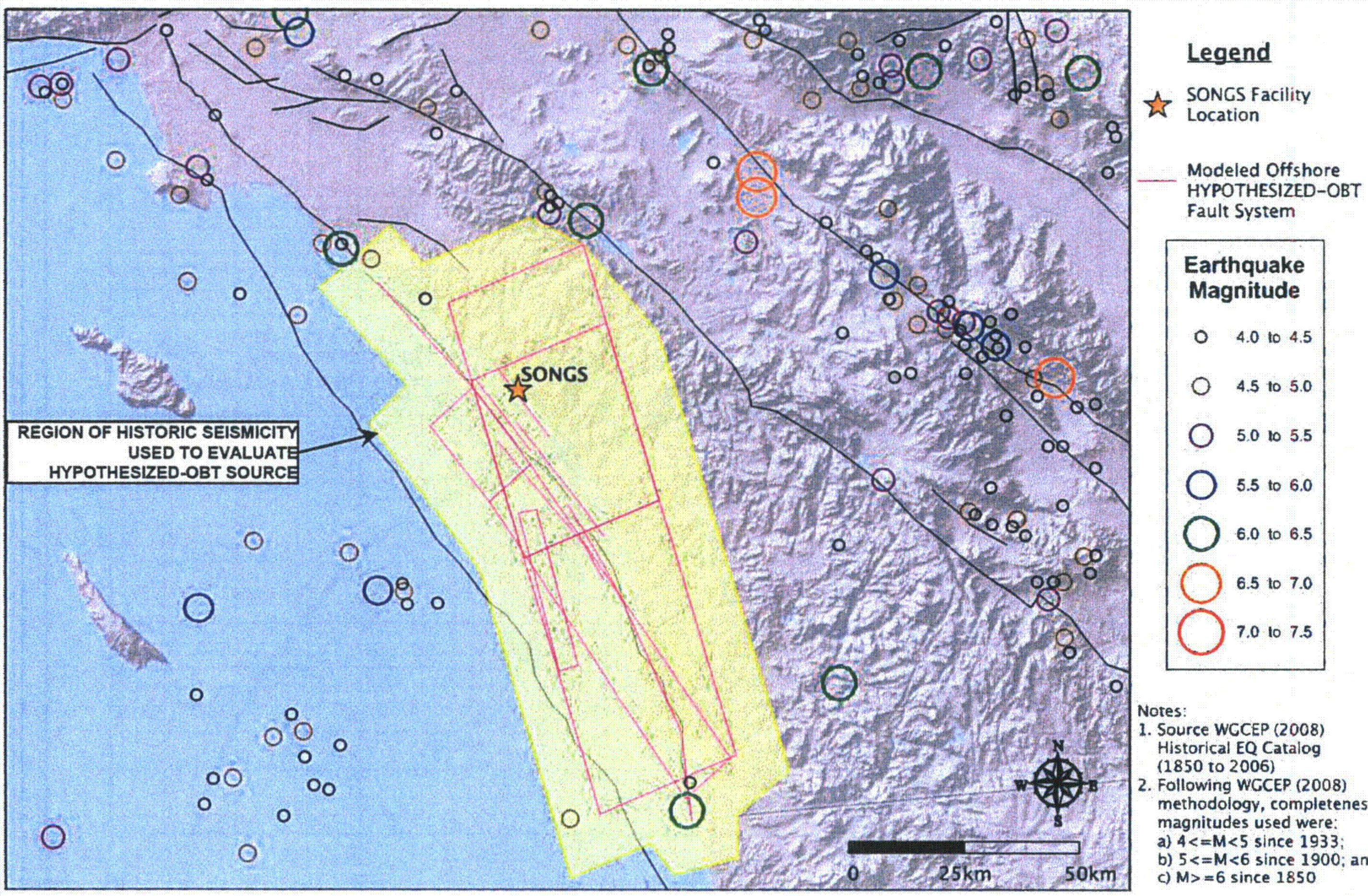
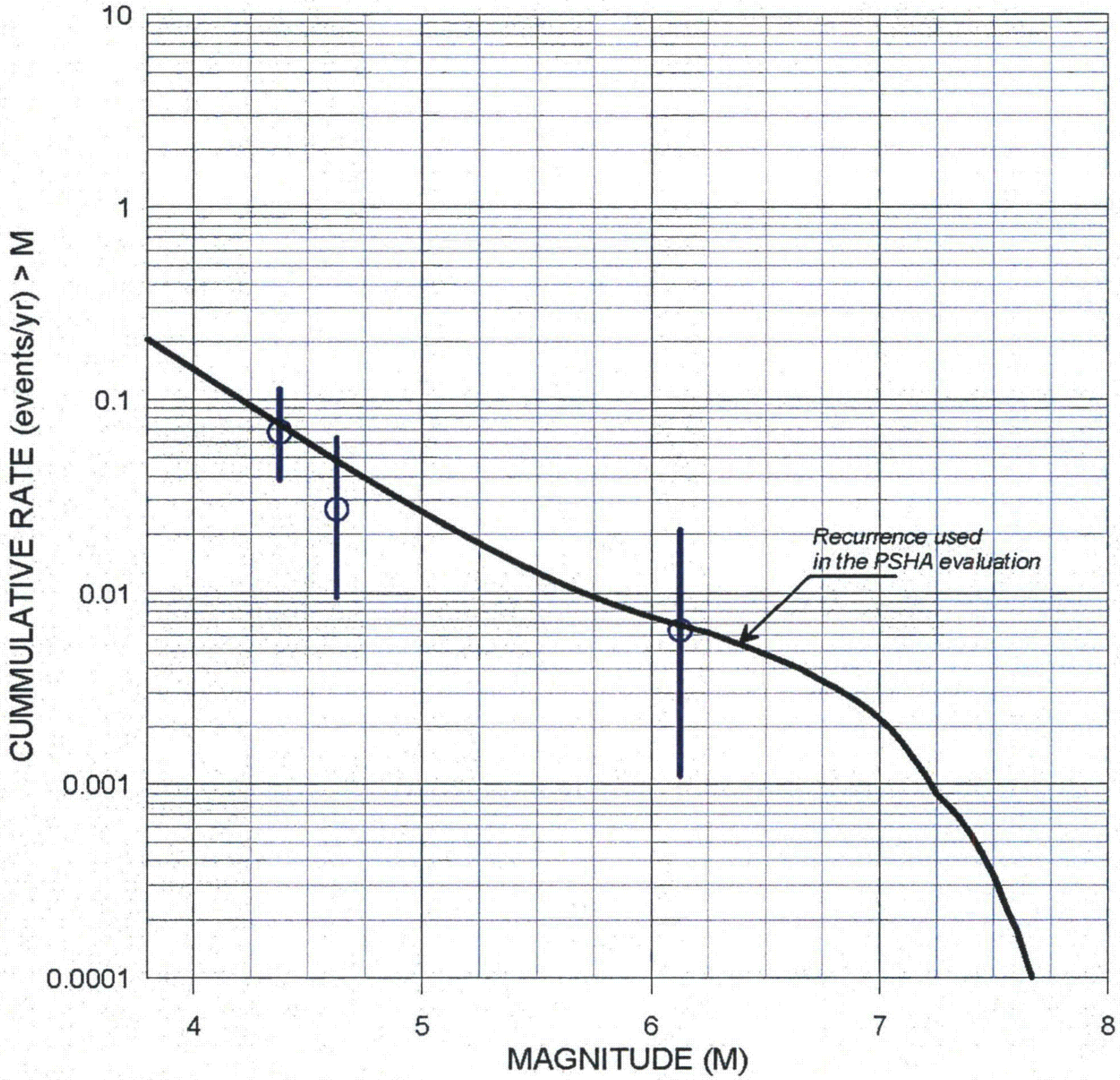
SAN ONOFRE NUCLEAR GENERATING STATION
SEISMIC HAZARD ASSESSMENT PROGRAM

COMPARISON OF THE dgnd TERM FOR THE 9 BINS CONSIDERED

FIGURE B-10



GeoPentech	SAN ONOFRE NUCLEAR GENERATING STATION SEISMIC HAZARD ASSESSMENT PROGRAM	HISTORIC SEISMICITY IN SONGS AREA AND REGION OF HISTORIC SEISMICITY USED TO EVALUATE OBT SOURCE	FIGURE B-11



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COMPARISON OF HISTORICAL AND MODEL RECURRENCES

FIGURE B-12

SAN ONOFRE NUCLEAR GENERATING STATION

SEISMIC HAZARD ASSESSMENT PROGRAM

Appendix 2

Tsunami Hazard Evaluation

TSUNAMI HAZARD EVALUATION

PURPOSE

A tsunami hazard evaluation was performed to evaluate tsunami vulnerability at the San Onofre Nuclear Generating Station (SONGS) in light of the recently published tsunami inundation maps as discussed below.

The "Tsunami Inundation Map for Emergency Planning," which was published June 1, 2009, for southern California's coastline in southern Orange County and northern San Diego County, was prepared jointly by the State of California Office of Emergency Services, the California Geologic Survey, the University of Southern California Tsunami Research Center, and the National Oceanic and Atmospheric Administration. A copy of this map is presented as Figure 1 and can be downloaded from the California Geological Survey's Website on tsunami information at http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/Pages/ index.aspx.

EVALUATION

As indicated on Figure 1, the red line shows a potential maximum tsunami inundation elevation of 17 to 20 feet (ft) above mean sea level (msl) or an equivalent elevation of 19.9 to 22.9 ft mean lower low water (mllw).

The tsunami inundation elevation shown on Figure 1 was created by the State of California (State) to identify a "credible upper bound" to the potential tsunami inundation at any location along the coastline. It was created by combining the ensemble of source events affecting the region, as summarized in Table 1 on Figure 1. In identifying the inundation elevation as a "credible upper bound," the State "adjusted the near shore bathymetric grids in their model to 'mean high water' sea level conditions *(which is higher than mean sea level by 2.6 ft)*[1], representing a conservative sea level for the tsunami modeling and mapping." This conservatism is reflected in the end result of the inundation map and shows the maximum elevation of the tsunami wave to be between elevations of 17 to 20 ft msl or the equivalent elevations of 19.9 to 22.9 ft mllw.

The top of the existing seawall at SONGS Units 2 and 3 is at an elevation of 30 ft mllw and, in the North Industrial Area, the top of the existing seawall is at an elevation of 28.2 ft mllw. The ground surface elevation of the site at SONGS Units 2 and 3 is the same as the top of the seawall so the State's map correctly represents the potential tsunami inundation, and there is no flooding at the location of SONGS Units 2 and 3. Utilizing the elevation at the top of the existing seawall and the estimated inundation elevations by the State, the existing seawall provides 7.1 to 10.1 ft of freeboard at SONGS Units 2 and 3.

As indicated on Figure 1, the North Industrial Area adjacent to and northwest of SONGS Units 2 and 3, is incorrectly shown as being inundated. As highlighted in the notes on Figure 1, under "Method of Preparation," the topography in the gridded area used to prepare the inundation map was enhanced by utilizing high-resolution digital topography from coastal interferomic data

Notes:
[1] Italicized note added to quote.

(circa 2003). This method did not detect the seawall due to its narrow profile. Therefore, during the preparation of the "Tsunami Inundation Map for Emergency Planning," the North Industrial Area seawall was inadvertently excluded and the inundation map erroneously indicated the potential for flooding. The existing seawall in the North Industrial Area will actually preclude flooding and provides 5.3 to 8.3 ft of freeboard above the State's estimated tsunami inundation elevations. To accurately reflect the actual layout of SONGS, Figure 2 was developed by showing the State's tsunami inundation line as it should be drawn in the vicinity of SONGS.

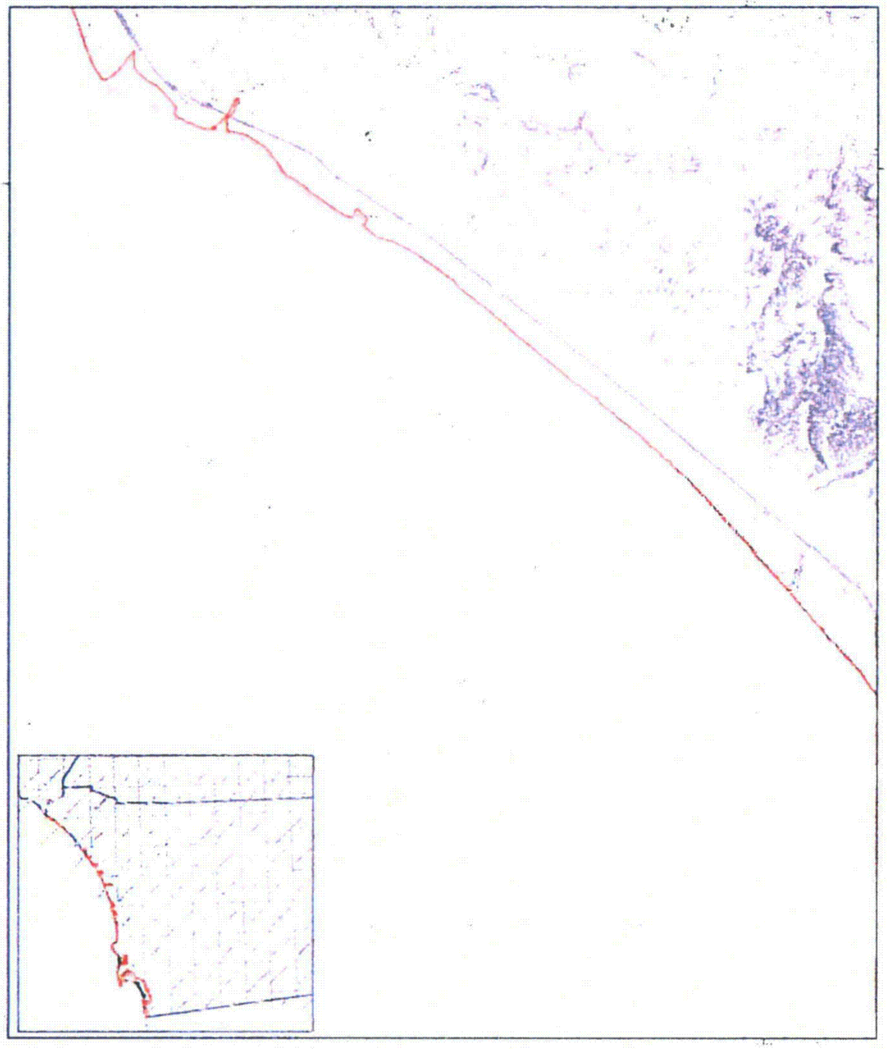
CONCLUSION

The estimated tsunami elevations shown on Figure 1, "Tsunami Inundation Map for Emergency Planning," do not identify any potential tsunami impacts or flooding to the SONGS site. The maximum elevation of the tsunami is about 23 ft mllw and the tops of the seawalls are at elevations of 30 ft mllw and 28.2 ft mllw for Units 2 and 3 and the North Industrial Area, respectively.

California Emergency Management Agency
California Geological Survey
University of Southern California

Tsunami Inundation Map for Emergency Planning
San Onofre Bluff Quadrangle

State of California
County of San Diego



METHOD OF PREPARATION

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of San Diego

SAN ONOFRE BLUFF QUADRANGLE

June 1, 2009

MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

PURPOSE OF THIS MAP

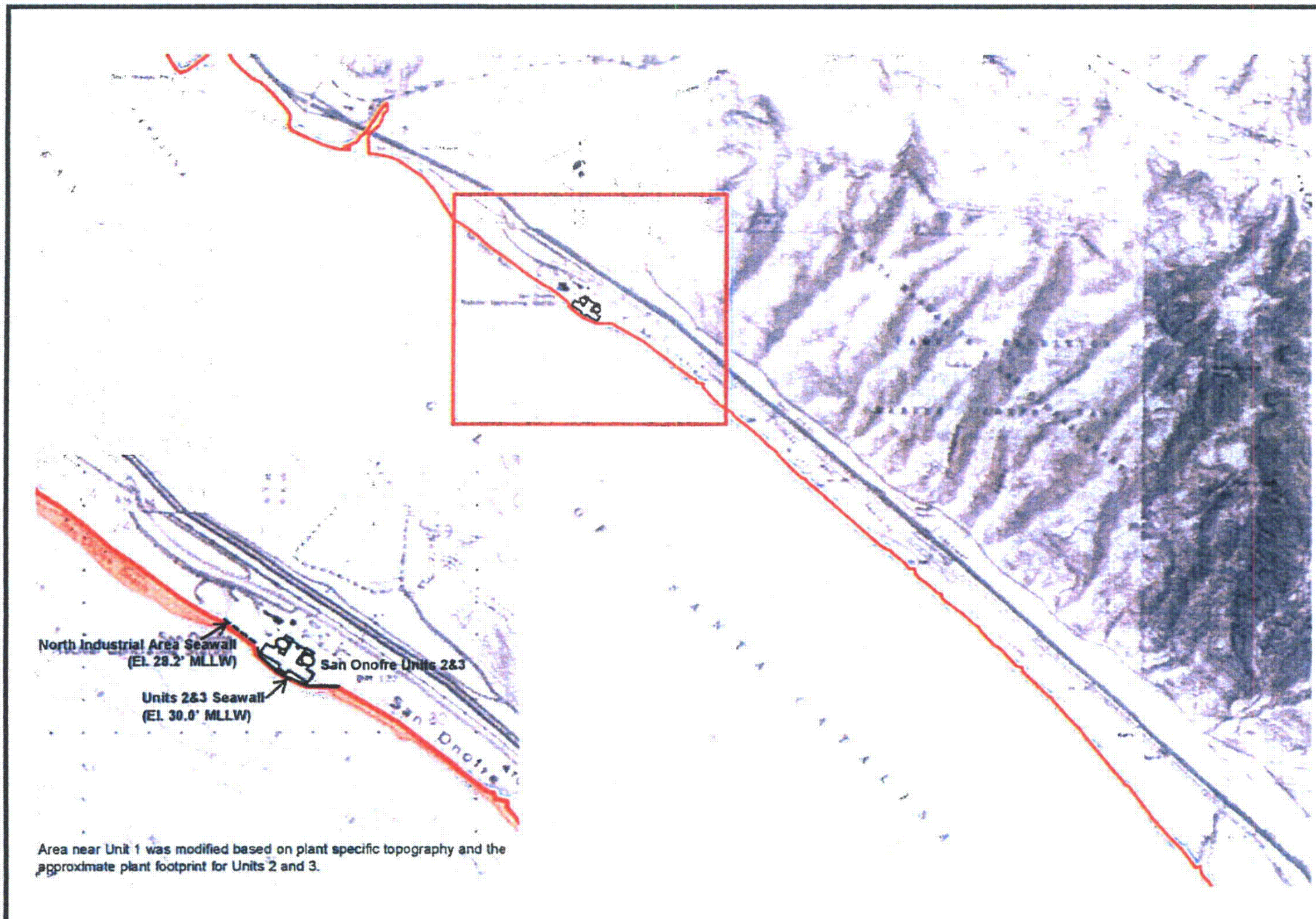
MAP BASE

DISCLAIMER

TSUNAMI INUNDATION MAP

GeoPentech

PROJECT: SONGS		
PROJECT #: 09024A	DATE: OCT 2010	FIG: 1



GeoPentech	MODIFIED TSUNAMI INUNDATION MAP	PROJECT: **SONGS**		
		PROJECT #: **09024A**	DATE: **OCT 2010**	FIG: **2**

Appendix 3

Lessons Learned from Kashiwazaki-Kariwa Nuclear Power Plant

SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL® Company

SAN ONOFRE NUCLEAR GENERATING STATION, Units 2&3

Lessons Learned from Kashiwazaki-Kariwa Nuclear Power Plant

Prepared by: Southern California Edison and Simpson Gumpertz & Heger

December 2010

LESSONS LEARNED FROM KASHIWAZAKI-KARIWA (KK) NUCLEAR PLANT

Table of Contents

Appendices

LESSONS LEARNED FROM KASHIWAZAKI-KARIWA (KK) NUCLEAR PLANT

1. INTRODUCTION

This report summarizes the lessons learned from the Kashiwazaki-Kariwa (KK) nuclear power plant following the 2007 Niigataken-Chuetsu-Oki (NCO) earthquake that occurred near the plant. The purpose of studying the lessons learned from the NCO earthquake near KK nuclear plant is to evaluate the potential for additional pre-planning or mitigation actions that could minimize plant outage times following a major seismic event at San Onofre Nuclear Generating Station (SONGS). This report identifies both the lessons learned from the KK nuclear plant following the NCO earthquake near the plant and the implications of those lessons learned to SONGS.

2. BACKGROUND ON THE NCO EARTHQUAKE AT KK

Based on the net electrical power rating, the KK plant is the largest nuclear generation facility in the world, with a total output of 7,965 megawatts (MW). This electrical output is sufficient to provide electricity to about 16 million households. The KK nuclear plant is located in the Niigata prefecture, on the northwest coast of Japan, and is operated by Tokyo Electric Power Company (TEPCO). The KK site has seven nuclear power units. Five reactors are of the boiling water reactor (BWR) type with a net installed capacity of 1,067 MW each. Two reactors are of the advanced boiling water reactor (ABWR) type with a net installed capacity of 1,315 MW each. The five BWR units commenced commercial operation between 1985 and 1994 and the two ABWRs commenced commercial operation in 1996 and 1997, respectively.

The KK nuclear plant is 16 kilometers away from the epicenter of the 2007 Niigataken-Chuetsu-Oki (NCO) earthquake (magnitude 6.6) that occurred on July 16, 2007. Ground motion recordings at the KK nuclear plant revealed that the NCO earthquake exceeded the seismic design level over a broad frequency range. Units 3, 4, and 7 automatically shutdown from 100 percent power when the units exceeded their seismic high-level shutdown set points. Unit 2 also automatically shut down during startup operations. Units 1, 5, and 6 were already shut down for planned outages at the time of the earthquake.

3. FINDINGS, LESSONS LEARNED AND IMPLICATIONS FOR SONGS

Since the occurrence of the NCO earthquake, extensive studies have been carried out by different organizations. These studies have resulted in a very broad range of lessons learned on the effects of the earthquake. Southern California Edison (SCE) has reviewed the following three reports that document the effects of the NCO earthquake on the KK nuclear plant:

- Institute of Nuclear Power Operations (INPO) Significant Event Notification SEN 269 on the Earthquake at Kashiwazaki-Kariwa, dated October 24, 2007 (INPO, 2007).
- Electric Power Research Institute (EPRI) Independent Peer Review of the TEPCO Seismic Walkdown and Evaluation of the Kashiwazaki-Kariwa Nuclear Power Plants, dated December 2007 (EPRI, 2007).

- International Atomic Energy Agency (IAEA) Mission Report on the Findings and Lessons Learned from the 16 July 2007 Earthquake at Kashiwazaki-Kariwa NPP, dated January 2009 (IAEA, 2009).

Some of the lessons learned in the referenced reports identified activities that were necessary since the NCO earthquake ground motions exceeded KK nuclear plant's seismic design basis. Activities associated with the exceedance of the design basis earthquake are not included in this SONGS study because the probability of an earthquake ground motion exceeding the SONGS design basis is extremely unlikely. SCE already had an established process to assure the complete evaluation of the impact to plant structures, systems and components (SSCs) in the remote event that an earthquake exceeded the design basis earthquake at SONGS. Additionally, during the initial design and licensing for SONGS, SCE performed extensive studies to identify and characterize faults near SONGS. These studies were used to determine the appropriate conservative ground motions from the nearby Newport–Inglewood/Rose Canyon (NI/RC) fault zone that were then factored into the plant's design.

3.1 INPO Significant Event Notice SEN 269

INPO routinely investigates events occurring at nuclear plants with the objective of identifying lessons learned from the events for the benefit of the entire nuclear power industry in the United States. INPO investigated the effects that the NCO earthquake had on the KK nuclear plant and documented the effects and lessons learned in the referenced report (INPO, 2007). Appendix A contains the detailed list of findings from the INPO report along with an assessment of how each of these findings, if applicable, relates to SONGS.

The key lessons learned from the INPO report are that:

- An integrated emergency response strategy and alternate methods of communication can improve the response to site wide events with multiple challenges.

- Fire protection capability for earthquakes should be assessed.

- Unintentional radiological liquid releases may occur following an earthquake.

- Seismic events can impact the integrity of radioactive waste storage drums or other items that are stacked without restraints.

- Items such as lighting fixtures, ventilation diffusers, cabinets, and materials should be seismically fastened in important operating spaces, such as in the main control room, to prevent falling objects from interfering with plant operations. use

3.2 EPRI Independent Review of the TEPCO Evaluation of KK

EPRI conducted an independent peer review to analyze various aspects related to the effects that the NCO earthquake had on the KK nuclear plant. The objective of EPRI's review was to assess the TEPCO seismic walkdown and evaluation program for the KK nuclear plant. The peer review used experts from the United States who possessed experience in conducting post-earthquake investigations, determining earthquake effects on power plants, and performing seismic qualifications (analysis and testing) for nuclear plant SSCs. The findings from EPRI's review, along with how those findings relate to SONGS, are documented in Appendix B.

The scope of EPRI's review consisted of the following tasks:

- Reviewing with TEPCO cognizant engineers the performance of the KK plant systems and equipment, during and following the July 16, 2007 earthquake.
- Completing a peer review on the key elements of the TEPCO program plan to assess the damage, assure continued safe shutdown, and assess a potential restart of the KK nuclear plant units.
- Completing peer review walkdowns on selected portions of the KK plant.
- Documenting the results of the peer review and walkdowns in an EPRI report.

The peer review included a "vertical slice" assessment of the KK nuclear plant's seismic review program, and involved sampling select elements of the TEPCO program. The areas that were peer reviewed included:

- Locations that exceeded the seismic design basis where the response had been measured.
- Critical safety-related (SR) SSCs that sustained visible damage based on a peer review walkdown as well as TEPCO's records that documented TEPCO's walkdowns, inspections and non-destructive examinations.

Specific peer review focus areas included:

- Damage and degraded conditions to SR equipment and structures.
- Damage to non-safety-related (NSR) equipment and structures.
- Results of the TEPCO post-earthquake evaluations, inspections and tests.
- Recommended additional inspections, non-destructive examinations and tests, if considered necessary.
- Recommended additional analyses, if considered necessary.
- Recommended supplemental in-service inspections and surveillance tests, if considered necessary.

The key lessons learned from the EPRI independent review are as follow:

- Comprehensive programs / procedures are required in order to address the effects of major seismic events at nuclear power plants.

- Instances of damage occurred to NSR SSCs at the KK nuclear plant as a result of the NCO earthquake.

3.3 IAEA Findings and Lessons Learned at KK

Following the NCO earthquake, the government of Japan through the Japanese Nuclear and Industrial Safety Agency (NISA) invited the IAEA to assess the preliminary findings and lessons learned from the NCO earthquake in order to share them with the international nuclear community. The assessment was completed from August 6, to August 10, 2007. In January 2008, six months following the earthquake event, a second IAEA assessment was conducted. The second assessment considered the results from the investigations and studies that were performed at KK nuclear plant up to that time, as well as any corrective actions that were implemented. Following an invitation from the Japanese government, an IAEA-led team of international experts conducted an additional review from December 1, to December 5, 2008, with their purpose being to discuss and share the lessons learned from the effects of the NCO earthquake on the KK nuclear plant. The team focused its efforts on Unit 7. The results from the IAEA's assessment and follow-up effort are documented in the IAEA report, dated January 29, 2009 (IAEA, 2009). Appendix C provides a summary of the IAEA findings related to the NCO earthquake, along with a discussion of the implications to SONGS.

The scope of the IAEA's assessment and follow-up efforts were as follows:

- To review the general approach and organizational structure used by the Japanese organizations (i.e., NISA, JNES, TEPCO) that were involved in responding to the earthquake.
- To assess of the results obtained from the inspection plan performed on the SSCs at the KK nuclear plant. Specifically, the status and final results of the integrity and functional inspections / investigations (i.e., documentation, reporting, etc.) performed on the SSCs for Unit 7 were reviewed to evaluate the behavior and response to the NCO earthquake.
- To review seismic safety. The following were obtained from seismic hazard investigations:
    - Status and results from the studies and investigations conducted as a follow up to the lessons that were learned during previous geophysical, geological, seismological studies and investigations performed on-shore and off-shore. This includes results associated with determining the new seismic hazard at the site, which is necessary for evaluating the seismic safety of the plant.
    - Status and results from the assessment of the seismic response of the SSCs to the NCO earthquake, including:
        a. An analytical simulation of the structural building response to the recorded ground motions from the NCO earthquake.
        b. A comparison with design values and assessment of margins;
        c. A comparison between the "original design seismic loads," "real seismic loads," and "limit state loads" for SSCs (analysis and / or tests).

d. A comparison between the "originally calculated" and "actually recorded / evaluated" response (i.e. floor response spectra).

- Status and results from the re-evaluation of the seismic safety based on the newly defined seismic hazard, including:

  a. The criteria that were selected for the re-evaluation of the seismic safety.

  b. Structural analyses of buildings and equipment.

  c. Seismic qualifications of the SSCs (e.g. analysis, testing, comparison, earthquake experience data).

  d. Results of the application of the evaluation criteria and decision and design on upgrades (if any).

The key lessons learned from the IAEA report are summarized below:

- TEPCO performed a re-evaluation of the seismic hazard at the site, which involved properly defining the ground motion that can result from a nearby fault.
- TEPCO evaluated the ground deformations. Results indicated that large ground deformations did not affect SR SSCs, but did affect road accessibility, water intakes, underground piping and facilities, electric switchyards, etc.
- TEPCO evaluated their fire protection response. As a result of the evaluation, a dedicated site fire brigade was established to be available at all times. New diverse water sources (underground tanks), water distribution piping above ground, and fire suppression upgrades in buildings were needed to improve response capabilities.

4. CONCLUSION

There are many lessons learned as a result of the NCO earthquake event and the impact it had on the KK nuclear plant. One key lesson is the need to properly determine the plant's seismic hazard and to revalidate the plant's design basis as new information becomes available. SCE has and continues to confirm the adequacy of the SONGS seismic design basis relative to the site's seismic setting. While the lessons to be learned from the three independent reports of the NCO earthquake near the KK nuclear plant are applicable to SONGS, a review of SONGS' design, processes and procedures confirmed that SONGS is properly designed and well prepared for a seismic event. The primary reason for SONGS being so well prepared for an earthquake is because SCE properly characterized the SONGS seismic hazard for its location in southern California and the plant was designed accordingly.

SCE determined the appropriate conservative ground motions from the nearby NI/RC fault zone when SONGS was originally designed and licensed. At that time, extensive studies were conducted to determine the existence and location of faults near SONGS in defining the seismic hazard at SONGS. In 1995, the validity of the original design in terms of the seismic hazard was confirmed to quantify the plant's seismic risk. This 1995 assessment included the review of relevant and updated earthquake information for the SONGS site. This assessment affirmed the adequacy of SONGS seismic design.

SCE has an active on-going seismic program to assess the seismic hazard for the SONGS site. This program reviews new seismic data and new developments in seismic research that are relevant to SONGS. The purpose of the program is to continually assess the seismic hazards that could affect the safe operation of SONGS.

The probability of earthquake ground motions exceeding the SONGS design basis is extremely unlikely. In the remote event that an earthquake exceeded the design basis earthquake at SONGS, SCE has an established process to assure that a complete assessment is conducted to evaluate the impact that an earthquake would have on the plant's SSCs.

SONGS operators have been and are trained to use written instructions on the actions to be taken when earthquake ground motions occur at the site. These actions include determining the earthquake accelerations so that the appropriate activities will be performed to ensure plant safety.

Much of the damage to the KK nuclear plant was caused by large ground deformations. The SONGS site will not have large ground deformations because the San Mateo soil, which was studied and tested prior to constructing SONGS, is not prone to liquefaction or large soil settlement during a seismic event.

Fire protection issues at KK nuclear plant have already been addressed at SONGS. SCE maintains a full-time dedicated fire department on-site and there are multiple alternative fire protection systems available to respond to fires.

The potential for unmonitored releases of radioactive liquids to the environment from the SONGS spent fuel pools was reviewed from the KK nuclear plant. In addition, the plant was reviewed under the Ground Water Protection Initiative that included the identification of possible radiological sources, the potential for system leakage, early detection techniques, spill containment features and mitigation measures. SCE has taken actions to minimize the potential for an unintended release.

As a result of the lessons learned review, one outstanding action was identified, which involves further evaluating the offshore discharge conduits for soil liquefaction and the potential effect on plant operation.

5. REFERENCES

EPRI Independent Peer Review of the TEPCO Seismic Walkdown and Evaluation of the Kashiwazaki-Kariwa Nuclear Power Plants: *A Study in Response to the July 16, 2007, NCO Earthquake,* EPRI Report 1016317, released for public August 6, 2009.

IAEA Mission Report on the Findings and Lessons Learned from the 16 July 2007 Earthquake at Kashiwazaki-Kariwa NPP, January 29, 2009.

GeoPentech, *San Onofre Nuclear Generating Station, Seismic Hazard Assessment Program, 2010 Probabilistic Seismic Hazard Report*; December 2010.

INPO Significant Event Notification SEN 269, *Earthquake at Kashiwazaki-Kariwa,* October 24, 2007.

San Onofre Nuclear Generating Station, Units 2 and 3, Updated Final Safety Analysis Report (UFSAR); Section 2.5, Geology, Seismology and Geotechnical Engineering.

Simpson, Gumpertz & Heger, *Seismic Reliability Study for San Onofre Nuclear Generating Station;* December 2010.

Southern California Edison, *Individual Plant Examination of External Events for San Onofre Nuclear Generating Station, Units 2 & 3;* December 1995 (contains the details of the SONGS probabilistic seismic hazard assessment and the seismic probabilistic risk assessment).

APPENDIX A - Assessment of INPO Findings	
INPO – KK Findings	**Discussion of Implications to SONGS**
1) An overall strategy is needed for managing site wide events resulting from multiple challenges. This strategy should be embedded in emergency response plans, processes, procedures, and training. Basic public services and systems lost during earthquakes or other natural disasters require strategies, contingencies, and prioritization schemes to respond to multiple challenges. The recommendations in SOER 02-1, Severe Weather, provide insights to consider in responding to a natural disaster. For natural disasters that cannot be predicted, such as earthquakes, the following lessons were identified:	SCE has an overall emergency response plan and procedures that consider the loss of basic public services from an emergency event and has contingencies and disaster strategies documented that address a wide range of emergencies that could occur at SONGS. Specific earthquake response plans and strategies are defined below.
a) Personnel resources and materials may be difficult to obtain immediately after natural disasters and need to be factored into emergency recovery plans, with realistic time frames for obtaining these resources.	The SONGS Emergency Response Organization (ERO) onsite at the time of the event would staff the Emergency Response Facilities, and a recall would be initiated for ERO members. Plant personnel responding to the event would work with local authorities, identifying themselves as SONGS ERO members, in order to access the site. Assigned members of the ERO are responsible for coordinating provisions for transportation, food, and other logistic support. They also act as a liaison with vendors to obtain additional resources such as manpower, equipment, supplies, transportation, and technical assistance to support recovery actions. Emergency procedures include the necessary actions for ERO members to take.

APPENDIX A - Assessment of INPO Findings	
INPO – KK Findings	**Discussion of Implications to SONGS**
b) Emergency recovery needs following natural disasters include near- and intermediate-term food supplies, temporary housing, drinking and domestic water, sewage treatment facilities, computer power supplies, and communication equipment alternatives and repair (such as mobile telephones and technicians capable of repairing communication equipment). These lessons were also identified during the Katrina hurricane in 2005.	There are emergency food and water supplies stored at various locations at SONGS, including the control area of the auxiliary building. Assigned members of the ERO would address other recovery needs. The SCE Information Technology department provides telecommunications technicians (as part of the SONGS' ERO) to repair damaged equipment. In addition, SONGS has at least six satellite phones on-site, and one at each of the California Highway Patrol (CHP) offices in San Juan Capistrano and Oceanside. There are also cell phones available, and a number of key SONGS' personnel have been issued Government Emergency Telecommunications Service (GETS) cards that give the user higher priority access to available communication circuits, whether land-line, cell phone or satellite phone. The SONGS computer servers are provided with backup power if offsite power is lost.

APPENDIX A - Assessment of INPO Findings

INPO – KK Findings	Discussion of Implications to SONGS
2) Seismic events can create vulnerabilities for station fire protection systems, support equipment, and fire-fighting personnel response. Fire system piping and tanks situated throughout the station can be damaged and local fire-fighting response may be delayed, requiring contingency plans. For example, the loss of fire protection water systems may require the use of dry chemical fire trucks, tanker trucks, or other backup contingencies.	SCE maintains a full-time "state registered" professional fire department on-site. In addition to plant fire suppression equipment, the San Onofre Fire Department (SOFD) is equipped with two fire engines (Type 1 fully equipped) with water and foam firefighting capabilities. The SOFD maintains post seismic readiness utilizing the North Industrial Area demineralized water storage tank (DWST), which is a 150,000 gallon seismically qualified water source with a seismically qualified mobile skid mounted pump. Water can be distributed to plant areas with fire hoses. Procedures are in place to implement this system and perform visual inspections of the plant should an earthquake occur. In addition, there are multiple alternate water sources available, including plant systems and non-plant city water. Multiple pumping sources are also available. Over and above these sources, the SOFD maintains mutual aid agreements with the Camp Pendleton Fire and Emergency Services (CPF&ES), located on the adjacent property, and with San Diego County. These agreements provide a large number of emergency resources (i.e., fire engines, foam crash trucks, tanker trucks, and air support) to SONGS in a timely manner. Further, the SOFD has a communication plan to ensure the ability to effectively communicate with all off-site responding agencies (including law enforcement, fire, and medical), using multiple radio frequencies. The SOFD conducts routine fire drills to verify that SONGS can effectively communicate with off-site responding agencies.

APPENDIX A - Assessment of INPO Findings

INPO – KK Findings	Discussion of Implications to SONGS
3) Items such as lighting fixtures, ventilation diffusers, cabinets, and materials should be securely fastened in offices and important operating spaces, such as in the main control room, to prevent falling objects from interfering with plant operations or injuring people.	Safe plant operation will not be affected by falling objects during and after an earthquake because SONGS seismic design criteria requires SR SSCs and NSR SSCs that could impact SR components to be designed to withstand a design basis earthquake. For example, the SONGS control room is seismically designed to ensure components like lights and ceiling panels do not fall during an earthquake. Furniture and office equipment are restrained accordingly to prevent movement and overturning. The operators have rules associated with good housekeeping for seismic considerations in the control room. Similarly, NSR plant office areas have a seismic design requirement to anchor or restrain items for earthquake to preclude personnel injuries.
4) Alternate methods of evacuating personnel from radiological controlled areas may need to be established, including designating backup locations for personnel contamination and alternate exit path monitoring.	Emergency Planning implementation procedures provide the methods for evacuating personnel from radiological controlled areas and the SONGS site. The procedure includes alternate locations for the site assembly areas, the use of unaffected pathways, and directing personnel to offsite reception centers when contamination is likely. The offsite Orange County reception center uses mobile showers for decontamination. San Diego has fixed showers for their reception center but also have mobile decontamination shower assets available if the fixed showers are unusable.

APPENDIX A - Assessment of INPO Findings

INPO – KK Findings	Discussion of Implications to SONGS
5) Radioactive waste storage drums and other portable radioactive waste containers need to be properly restrained if stacked.	Drums and low specific activity (LSA) boxes containing solid low level radioactive waste are stored in the SONGS Multipurpose Handling Facility (MPHF) and may be double-stacked. Limiting the stacking height will minimize the possibility of movement and overturning of the containers. The radioactive drums at the KK nuclear plant were stacked up to three levels which increased their seismic instability. Even if the containers were to fall during an earthquake, the MPHF is designed to preclude waste from being unintentionally released to the environment. Stacked cargo containers or radioactive equipment material storage (REMS) boxes are located outdoors and are procedurally required to be seismically secured to prevent overturning.

APPENDIX A - Assessment of INPO Findings	
INPO – KK Findings	**Discussion of Implications to SONGS**
6) Leaks occurring during a seismic event could result in an unplanned discharge of contaminated liquid to the environment through unmonitored release paths. Guidance may be required to monitor and control these paths during seismic events. Sump pumps located adjacent to radiological controlled areas that could provide unmonitored discharge to the environment should be turned off if unexplained inputs are encountered. Alternatively, sumps with the p The potential for unmonitored releases should be considered for *monitoring and processing through radioactive waste processing* systems.	The potential for unmonitored releases of radioactive liquids to the environment was reviewed. Specifically, the potential for water spillage from the spent fuel pool was considered in the design of the Fuel Handling Buildings. In the unlikely event that water were to spill out of the spent fuel pool, it would go to the building sump and be managed consistent with station procedures for the control of radioactive liquids. In addition, as part of SCE's implementation of the industry Ground Water Protection Initiative, SCE evaluated the potential for unintended releases due to equipment leakage or human error. The review included the identification of possible radiological sources, the potential for system leakage, early detection techniques, spill containment features and mitigation measures. SCE has taken actions to minimize the potential for unintended releases and to enhance its groundwater protection program.

APPENDIX A - Assessment of INPO Findings

INPO – KK Findings	Discussion of Implications to SONGS
7) Transformer structures, designed to contain oil leaks, may become compromised during a seismic event. Methods of mitigating the spread of transformer oil into the environment, such as the use of temporary berms or the blocking of alternate oil release paths, should be considered.	If a transformer leaked oil, the transformer berm would contain and prevent the oil from going into the surrounding soil and the groundwater below the site. Mitigation of any oil spill beyond the berm would be accomplished by hazmat responders, who are trained to use temporary containment measures. If the valve or the drain line was broken, the hazmat emergency response rig has the capability to plug drain lines. It also has the capability to either pump liquids from one berm to another if the integrity of a berm was degraded or transfer the oil to the oily waste system within the plant. This could be done by simply utilizing a diesel pump to transfer the oil to the oily waste system. To enable the use of another drain pathway in an emergency is an option that could be completed with the existing hazmat emergency response teams' equipment, and within the incident command structure. The hazmat emergency response team also has portable tanks, as well as an empty tanker that could be utilized in an emergency. Vacuum trucks are available through subcontractors and can be brought on-site.
8) Seismic events can result in the actuation of blowout panels and tornado dampers that may adversely affect secondary containment or other important ventilation systems. Station procedures should provide guidance for these potential conditions.	SONGS has a pressurized water reactor system and there is no secondary containment as in BWR systems. Thus, there are no blowout panels and tornado dampers inside the containment structure and this finding is not applicable to SONGS.

APPENDIX B - Assessment of EPRI Findings

EPRI – KK Findings	Discussion of Implications to SONGS
1) Comprehensive programs / procedures are required in order to address the effects of significant earthquakes at nuclear power plants. These procedures should include three fundamental areas (as defined in ANSI/ANS Standard 2.23): – Visual inspections – Operability reviews and assessments – Detailed inspections, testing, and analyses	SCE has an operating instruction for responding to earthquakes and the instruction requires operator actions, visual inspections, testing, and evaluations as specified in ANSI/ANS Standard 2.23. The amount of detailed inspections, testing, and evaluations to be performed is dependent on the level of the ground motions recorded at SONGS.
2) SR structures at the KK nuclear plant performed well during and following the NCO Earthquake. Based on the sampling visual inspections performed as a part of this peer review, KK SR SSCs performed very well in response to the NCO earthquake. No significant damage was detected by visual inspection on the representative SR SSCs reviewed.	SR SSCs have been designed to the design basis earthquake level and have seismic margin beyond those levels at SONGS.
3) Instances of damage occurred to NSR SSCs at the KK nuclear plant as a result of the NCO earthquake. The key examples of NSR damage noted in the EPRI study included:	A discussion of the implications to SONGS is provided for each of the NSR SSCs listed below.
a) House transformer fire	The house transformer fire was the result of ground settlement following the earthquake. Studies have verified that the SONGS site is not vulnerable to liquefaction or large soil settlement. The studies are documented in the Section 2.5 of the SONGS Updated Final Safety Analysis Report (UFSAR) (SONGS, UFSAR).

APPENDIX B - Assessment of EPRI Findings

EPRI – KK Findings	Discussion of Implications to SONGS
b) Outside tank failures (e.g., buckling, attached piping failures, and tank wall ruptures)	Large unanchored vertical tanks are vulnerable to buckling damage and attached piping failures. The SONGS large vertical tanks were reviewed in the SONGS seismic reliability study. Only the unanchored makeup demineralized water tanks were found to be vulnerable to a major earthquake. SCE has a backup plan to bring in portable tanks and pumps in order to maintain a demineralized water source and to continue generating electricity in the event that the makeup demineralized water tank fails.
c) Underground fire suppression piping failures	The underground fire water piping failures at the KK nuclear plant were induced by soil settlement and liquefaction. Studies have verified that the SONGS site is not vulnerable to liquefaction or large soil settlement. Even if there were to be fire water piping failures, there are multiple alternative water and pumping sources available to the SONGS fire fighters.
d) Yard structure foundation failures and subsidence (liquefaction induced)	The yard structure failures at the KK nuclear plant were induced by soil settlement and liquefaction. Studies have verified that the SONGS site is not vulnerable to liquefaction or large soil settlement.

APPENDIX B - Assessment of EPRI Findings		
	EPRI – KK Findings	Discussion of Implications to SONGS
e)	Stack and transmission tower damage	The damaged exhaust stack and steel transmission tower are both tall structures with large aspect ratios at the KK nuclear plant. The steel transmission tower damage was a single brace failure which did not result in power disruption. Since the single damaged brace was the only damaged element found among numerous towers at the KK nuclear plant site, it was concluded that there may have been a defect in the damaged brace connection. Transmission towers at SONGS are designed for greater than building code force levels and have a large ductility that provides a high seismic margin. Other SCE towers similar to the SONGS towers have sustained base damage in prior earthquakes, however, the towers remained functional and the damage was repaired in a very short time. The SONGS units, being pressurized water reactors, do not have a large exhaust stack similar to the ones at the KK nuclear plant, which are BWR units.
f)	Pump house foundation and structure failures	The pump house at the KK nuclear plant failed due to an improperly designed foundation which separated when the soil foundation subsided during the earthquake. The foundation for this pump house was expanded two separate times using different foundation designs and were improperly tied together. This unique modified building foundation is not an issue at SONGS because building foundations have not been expanded and significant soil settlements will not occur in an earthquake at the SONGS site.

APPENDIX B - Assessment of EPRI Findings	
EPRI – KK Findings	**Discussion of Implications to SONGS**
g) Water treatment component anchorage failures	The anchorage for NSR SSCs was reviewed in the SONGS seismic reliability study. SONGS mechanical components are anchored for loadings that exceed building code requirements.
h) Falling control room ceiling items (e.g., light fixtures and ceiling diffusers)	Safe plant operation will not be affected by falling objects during and after an earthquake because SONGS seismic design criteria requires SR SSCs and NSR SSCs that could impact SR components to be designed to withstand a design basis earthquake. For example, the SONGS control room is seismically designed to ensure components like lights and ceiling panels do not fall during an earthquake. Furniture and office equipment are restrained accordingly to prevent movement and overturning. The operators have rules associated with good housekeeping for seismic considerations in the control room.
4) The KK turbines exhibited some anomalies during the NCO earthquake. The main turbines in Unit 7 were reviewed by EPRI and resulted indicated that a high vibration alarm occurred during the earthquake, but tripped as a result of the automatic scram signal. TEPCO reported that was possible cause was due to the turbine shafts showing some shifting and bearing damage.	During the TEPCO post-earthquake evaluation, the turbines were disassembled and inspected for damage. While several bearings had light contact marks (including turbine bearings that were not in operation during the earthquake), there were no anomalies that would have prevented post-earthquake operation of the turbines. The SONGS turbines have been evaluated in the SONGS seismic reliability study and found to have a high seismic capability. Turbine damage due to direct shaking during a seismic event is unlikely. See the SONGS Seismic Reliability Study report for additional details (Simpson, Gumpertz & Heger, 2010).

APPENDIX B - Assessment of EPRI Findings	
EPRI – KK Findings	**Discussion of Implications to SONGS**
5) Unanchored and poorly anchored components failed in the earthquake. In the control rooms of Units 6 and 7, several overhead lighting fixtures fell, an unanchored copy machine toppled over, one or more HVAC diffusers fell to the floor, and documents on shelves typically fell out. No significant damage was apparent and reportedly no operators were injured.	Safe plant operation will not be affected by falling objects during and after an earthquake because SONGS seismic design criteria requires SR SSCs and NSR SSCs that could impact SR components to be designed to withstand a design basis earthquake. For example, the SONGS control room is seismically designed to ensure components like lights and ceiling panels do not fall during an earthquake. Furniture and office equipment are restrained accordingly to prevent movement and overturning. The operators have rules associated with good housekeeping for seismic considerations in the control room.
6) TEPCO operators followed proper procedures following the earthquake by responding to alarms, verifying safe and stable conditions, and implementing a formal earthquake response procedure.	SONGS has an earthquake response procedure for earthquakes. The operators are trained on the procedure and demonstrate their proficiency during drills.
7) Emergency Communications had problems following the earthquake. The access door to the Technical Support Center in the Administrative Building was stuck shut for about 45 minutes following the earthquake, preventing access of personnel to the instrumentation and communication equipment in the Technical Support Center.	SCE maintains an emergency offsite facility (EOF) which is designed for Uniform Building Code (UBC) levels of seismic loading. The heavy shielding doors of the SONGS EOF are always propped open so access will not be an issue like the binding door scenario that the KK nuclear plant experienced. Also, the doors can be closed if required to protect the occupants of the facility due to the robust structural strength of the reinforced concrete walls.

APPENDIX B - Assessment of EPRI Findings

EPRI – KK Findings	Discussion of Implications to SONGS
8) The general yard area and roadways showed relatively extensive ground ruptures and subsidence due to liquefaction.	Studies have verified that the SONGS site is not vulnerable to liquefaction or large soil settlement.
9) The switchyard in the KK nuclear plant performed extremely well given the very large accelerations from the NCO earthquake. The main components of the NSR switchyard are founded on a single foundation. This foundation and the anchorages of main components were said to be designed for a static acceleration of 0.2g and appeared to be capable of withstanding significantly larger loads. Two of the four power feeds continued to supply power throughout the earthquake. The two which were not available were disconnected by protective relaying due to off-site transmission and distribution problems (i.e., power line slapping, insulator failures, and relay malfunctions). The only anomalies reported in the actual switchyard components were a control cabinet (mounted next to, but not on the engineered foundation) which tipped slightly but continued to function and damage to a termination plate at the top of a bushing stack which broke an oil seal.	The SONGS switchyard was reviewed as part of the SONGS seismic reliability study. While the power circuit breakers have been designed to withstand earthquakes, the SONGS standard dead end tower configuration and line drops to switches may sustain damage to the suspended components and the adjacent switches. Such earthquake damage is common to substation apparatus and can be quickly repaired.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Specific Lessons Learned	
1) A re-evaluation of the seismic hazard at the site is necessary. This entails properly defining the ground motion that can result from a nearby fault. Also, it is necessary to perform a probabilistic analysis of the ground motion and fault displacements.	During initial licensing SCE had already determined the appropriate conservative ground motions from the nearby NI/RC fault zone. At that time, extensive studies were conducted to identify faults near SONGS and define the seismic hazard at SONGS. These studies and evaluations are documented in the Section 2.5 of the UFSAR (SONGS, UFSAR). In 1995, a probabilistic seismic hazard assessment was performed to quantify the plant's seismic risk and the assessment included the review of relevant updated earthquake information for the SONGS site. The SONGS' seismic probabilistic risk assessment is updated accordingly to reflect any new seismic information that becomes available.
2) Large ground deformations did not affect SR SSCs, but did affect road accessibility, water intakes, underground piping and facilities, electric switchyards, etc.	The SONGS site will not have large ground deformations because the San Mateo soil was studied and tested to not be vulnerable to liquefaction or large soil settlement. The studies are documented in the Section 2.5 of the SONGS UFSAR (SONGS, UFSAR).
3) SR anchorages performed very well during the intensive seismic shaking.	The SONGS equipment is anchored as required by the SONGS seismic design criteria and will withstand seismic events without loss of function.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
4) Dedicated site fire brigade was available at all times. New diverse water sources (i.e., underground tanks), above ground water distribution piping, and fire extinguishing upgrades in buildings were needed to improve response capabilities.	SCE maintains a full-time "state registered" professional fire department on-site. In addition to plant fire suppression equipment, the SOFD is equipped with two fire engines (Type 1 fully equipped) with water and foam firefighting capabilities. The SOFD maintains post seismic readiness utilizing the North Industrial Area DWST, which is a 150,000 gallon seismically qualified water source with a seismically qualified mobile skid mounted pump. Water can be distributed to plant areas with fire hoses. Procedures are in place to implement this system and perform visual inspections of the plant should an earthquake occur. In addition, there are multiple alternate water sources available, including plant systems and non-plant city water. Multiple pumping sources are also available. Over and above these sources, the SOFD maintains mutual aid agreements with the CPF&ES, located on the adjacent property, and with San Diego County. These agreements provide a large number of emergency resources (i.e., fire engines, foam crash trucks, tanker trucks, and air support) to SONGS in a timely manner. Further, the SOFD has a communication plan to ensure the ability to effectively communicate with all off-site responding agencies (including law enforcement, fire, and medical), using multiple radio frequencies. The SOFD conducts routine fire drills to verify that SONGS can effectively communicate with off-site responding agencies.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Lessons Learned from Findings Sheets	
Finding A.1-01 Exceedance of the Design Basis Ground Motion by the Earthquake	
Fault Mechanism and Directivity Near source fault effects are to be considered in the seismic hazard.	These effects were evaluated in the probabilistic seismic hazard assessment for SONGS in 2001. The result of adding these effects was an insignificant change to the seismic risk of the plant.
Local Geological Conditions Differences in the site geology need to be considered for all units.	Site geology is the same for SONGS Unit 2 and Unit 3. Both are underlain with San Mateo formation to the same depth as documented in Section 2.5 of the UFSAR (SONGS, USFAR).
Attenuation Relationships Attenuation relationships play an important part in seismic hazard assessments and there has been new equations developed from the recent available earthquake records. When seismic sources are present near the site vicinity, it is necessary to take into consideration the recent records obtained in the near field.	Since the construction of SONGS, there have only been small ground motions recorded due to distant earthquakes, like the Northridge and Landers earthquakes. There are no recent earthquake records near SONGS that can be used to determine a specific attenuation relationship for SONGS. The latest developed attenuation relationships are used for the probabilistic seismic hazard updates for SONGS.
Accounting for Uncertainties Identification and quantification of aleatory (random) and epistemic (modeling) uncertainties are very important and is usually not straightforward. The data used needs to be qualified in terms of its reliability and the methods need to allow for alternative models.	The SONGS probabilistic seismic hazard incorporates both the aleatory and the epistemic uncertainties. These uncertainties are documented in the SONGS seismic hazard report.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Importance of Seismic Instrumentation Immediate indication to the operator of the severity of earthquake needs to be considered.	The SONGS seismic instrumentation provides the data to the operators and engineers when an earthquake occurs. SONGS earthquake procedure describes the analysis requirements for determining the seismic accelerations when an earthquake's ground motions are recorded at the plant.
Finding A1-02 Re-Evaluation of the Seismic Hazard	
Need for Strengthening of the Database to Decrease Uncertainties Investigations both on land and offshore would significantly enhance the geological database and help in reducing uncertainties regarding fault existence, location, and characterization.	SCE determined the appropriate conservative ground motions from the nearby NI/RC fault zone when the plant was licensed. At that time, extensive studies were conducted in looking for faults near SONGS and defining the seismic hazard at SONGS. These studies and evaluations are documented in the Section 2.5 of the UFSAR. In 1995, a probabilistic seismic hazard assessment was performed to quantify the plant's seismic risk and the assessment included the review of relevant updated earthquake information for the SONGS site. This assessment affirmed the adequacy of the SONGS seismic design. An on-going seismic program is in place to review the seismic setting in the vicinity of SONGS as seismic understanding evolves and new data becomes available.
Use of Deterministic and Probabilistic Methods Probabilistic seismic hazard will be needed to quantify the variety of seismotectonic settings and their uncertainties. This would be used in a probabilistic seismic hazard analysis of the plant.	SCE conducted a probabilistic seismic hazard assessment in 1995. The probabilistic seismic hazard assessment is updated to incorporate new seismic information as part of an on-going seismic program that continually reviews the seismic hazard at SONGS.

APPENDIX C - Assessment of IAEA Findings

IAEA – KK Findings	Discussion of Implications to SONGS
Faults in Near Region Fault mechanisms and directivity can play an important role in a near fault ground motion.	The SONGS seismic hazard uses attenuation relationships which incorporate these concepts. These effects were evaluated in the probabilistic seismic hazard assessment for SONGS in 2001. The result of adding these effects was an insignificant change to the seismic risk of the plant.
Local Geological Conditions The variation of the geological conditions both in terms of age and depth played a role in the damage patterns to NSR items at the KK nuclear plant.	Site local geology is the same for SONGS Unit 2 and Unit 3. Both are underlain with San Mateo formation to the same depth as documented in Section 2.5 of the UFSAR (SONGS, UFSAR).
Construction of Seismotectonic Model	Seismic hazard for SONGS includes the proper characterization of uncertainties, and different seismic source models, such as fault lengths and fault capabilities, in predicting the probabilistic seismic hazard.
Treatment of Uncertainties	The SONGS probabilistic seismic hazard incorporates both the aleatory and the epistemic uncertainties. These uncertainties are documented in the SONGS seismic hazard report.
Ground Motion Characterization	The latest attenuation relationships are being used for the current probabilistic seismic hazard update for SONGS.
Assessment of Potential Surface Faulting at the Site	Not applicable to SONGS. Based on-site excavations at the time of the plant construction, no credible surface faulting exists or was found within the plant boundary.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Soil Failures at the Site	Studies have verified that the SONGS site is not vulnerable to liquefaction or large soil settlement. The studies are documented in the Section 2.5 of the SONGS UFSAR (SONGS, UFSAR).
Probabilistic Seismic Hazard Analysis	SCE conducted a probabilistic seismic hazard assessment in 1995. The probabilistic seismic hazard assessment is updated to incorporate new seismic information as part of an on-going seismic program that continually reviews the seismic hazard at SONGS.
Finding A2-01 Offsite Power	
The loss of offsite power for earthquake events greater than 0.25g may be conservative in countries like Japan where seismic design of electric facilities is relatively advanced.	The finding acknowledges the conservatism of assuming an earthquake will cause the loss of offsite power. However, SCE has and will continue to conservatively assume the loss of offsite power in its accident scenarios in response to a seismic event.
Finding A2-02 Seismic System Interactions	
Diligence is required in the design, construction, and operation of all plants to ensure seismic system interaction issues are minimized.	SCE performed a system interaction review as part of the seismic probabilistic risk assessment in 1995, which remains valid today. The system interactions included seismic induced fire and flooding, and seismic interaction of NSR components.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Plant walkdowns performed to evaluate conditions for potential seismic vulnerabilities should extensively consider the potential consequences of failures due to non-seismic conditions.	Plant walkdowns were conducted by experienced and trained engineers in doing the system interaction review for the seismic probabilistic risk assessment in 1995. The walkdowns identified some potential vulnerabilities such as closely spaced electrical panels and a non SR ammonia tank. These vulnerabilities were addressed to preclude failure during a design basis earthquake event.
A seismic system interaction program for spray and flooding hazards should be implemented to verify the lack of failure of sources of water and / or verify that no negative consequences to SR equipment if leaks or failures occur.	SCE performed a system interaction review as part of the seismic probabilistic risk assessment in 1995, which remains valid today. The system interactions included seismic induced fire and flooding, and seismic interaction of NSR components.
The capacities of non SR SSCs should be verified when considering the new seismic hazard for seismic evaluation of existing nuclear power plants.	The review of NSR SSCs is documented in the SONGS seismic reliability report.
Finding A2-03 Fire Protection	
Seismically induced fires are frequent events after an earthquake in urbanized areas, but are relatively rare at a nuclear power plant.	A seismic / fire interaction review and walkdown were conducted as a part of the seismic probabilistic risk assessment in 1995 at SONGS. The review did not reveal any vulnerability that would have significantly increased the plant's seismic / fire risk.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Common cause failure should be avoided. Failure of the fire fighting system (including tanks, pumps, piping, and distribution systems) and its consequences can be minimized by providing adequate seismic capacity, redundancy, and diversification of the systems.	SCE maintains a full-time "state registered" professional fire department on-site. In addition to plant fire suppression equipment, the SOFD is equipped with two fire engines (Type 1 fully equipped) with water and foam firefighting capabilities. The SOFD maintains post seismic readiness utilizing the North Industrial Area DWST, which is a 150,000 gallon seismically qualified water source with a seismically qualified mobile skid mounted pump. Water can be distributed to plant areas with fire hoses. Procedures are in place to implement this system and perform visual inspections of the plant should an earthquake occur. In addition, there are multiple alternate water sources available, including plant systems and non-plant city water. Multiple pumping sources are also available. Over and above these sources, the SOFD maintains mutual aid agreements with the CPF&ES, located on the adjacent property, and with San Diego County. These agreements provide a large number of emergency resources (i.e., fire engines, foam crash trucks, tanker trucks, and air support) to SONGS in a timely manner. Further, the SOFD has a communication plan to ensure the ability to effectively communicate with all off-site responding agencies (including law enforcement, fire, and medical), using multiple radio frequencies. The SOFD conducts routine fire drills to verify that SONGS can effectively communicate with off-site responding agencies.

APPENDIX C - Assessment of IAEA Findings

IAEA – KK Findings	Discussion of Implications to SONGS
Large soil settlements can cause piping failure. Flexible joints, flexible penetrations, protective buried channels, and other means could be used to minimize the probability of failure.	Not applicable to SONGS. Large settlements are not expected at SONGS due to the competent soil. In addition, alternate sources of fire suppression exist at SONGS if the underground fire water piping were to fail. These alternate sources include foam fire fighting as well as additional water sources (alternate water tanks and pumps with hoses are part of the emergency fire fighting plan).
For nuclear power plants located in coastal areas, corrosion problems could affect the resistance of fire protection systems exposed to the exterior environment. The use of corrosion resistant material and the implementation of an adequate inspection program will be important to prevent unexpected failures due to earthquake occurrence.	SCE has a maintenance program which inspects fire protection equipment for degradation including the effects of corrosion. Also, SCE maintains cathodic protection for underground piping, and has a program to evaluate the condition of underground piping. Since fire protection systems are quality affecting at SONGS, nonconforming or degraded conditions are identified and placed in the plant's corrective action program. Therefore, the SONGS fire protection system is maintained and monitored to preclude unexpected failures.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
It would be helpful to give due consideration to important aspects, such as secondary effects of fire suppression systems, spurious operation of automatic fire protection systems, and fire related explosions.	Consideration of these aspects was given with respect to their effects on the SR systems at SONGS. The lessons learned from KK nuclear plant on fire protection system failures and fires from the earthquake identified soil failure and the resulting large deformations imposed on the system equipment. SONGS has studied the potential for soil failures as a result of a large earthquake and found those soil related failure modes to not be applicable to SONGS because the San Mateo soil will not have significant soil settlements or soil liquefaction. The studies are documented in the Section 2.5 of the SONGS UFSAR (SONGS, USFAR).
The confirmation of appropriate staffing of the in-house fire brigade including addressing the scenarios involving the occurrence of multiple fires should be completed.	SCE maintains a full-time "state registered" professional fire department on-site. A required minimum staffing level is maintained at all times that is sufficient to respond to events involving multiple fires.
Communications with the local authorities, media, and the public during emergency situations can be made easier by establishing a permanent dialogue between stakeholders, the regulators, and the licensees.	SONGS emergency response team has a thorough set of procedures which include communication requirements with all affected stakeholders and regulators in the event of an emergency such as an earthquake. Also see above for more details about the communication plan.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
First responders to fires from a major natural disaster should not be restrained from performing their functions due to failure of their systems.	The fire protection systems at SONGS have multiple sources to ensure that even if a particular system were to fail, that there are backup systems to ensure fire protection capability. These backup systems include alternate water sources and a fire pump that can use hoses for obtaining water from tanks.
Seismic design of fire brigade building should be similar to the seismic design criteria used for other critical portions of the nuclear plant and should not collapse.	SONGS has a fire protection system that has the capability to withstand the design basis earthquake. The system is located outdoors and includes a water storage tank and diesel powered pump with the use of fire hoses. The fire fighters are housed in a portion of the AWS Building that would not collapse during a design basis earthquake.
Finding A2-04 Soil Deformation	
In case of large seismic shaking, large ground deformations are frequently inevitable. Nevertheless, measures to limit their effects could be taken.	Not applicable to SONGS because the San Mateo soil will not have significant soil settlements or soil liquefaction. Studies have verified that the SONGS site is not vulnerable to liquefaction or large soil settlement. The studies are documented in the Section 2.5 of the SONGS UFSAR (SONGS, UFSAR).

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Backfilling measures could be taken including the use of proper soil materials for backfill and proper soil compacting, the protection of the penetration by expansion joints that can allow large displacements and/or concrete channels to protect the underground piping, lowering groundwater levels, etc.	SONGS backfill requirements used only San Mateo soil or a cement-sand slurry mix. These materials provided similar soil properties to the native San Mateo soil and thus will not have significant soil settlements or soil liquefaction.
Although the observed large ground deformations did not affect SR SSCs, these ground deformations had an influence on the overall performance of the plant including impeding the ability to carry out immediate actions following an earthquake. Road accessibility, water intakes, underground piping and facilities, electrical switchyards, etc. could be significantly and adversely affected by large ground deformations.	Not applicable to SONGS because the San Mateo soil is not subject to significant soil settlements or soil liquefaction. Studies have verified that the SONGS site (onshore) is not vulnerable to liquefaction or large soil settlement. The studies are documented in the Section 2.5 of the SONGS UFSAR (SONGS, UFSAR). The NSR offshore discharge conduits may be affected by soil liquefaction offshore as identified in the SONGS Seismic Reliability Study report (Simpson, Gumpertz & Heger, 2010). The offshore conduits will be evaluated to determine the potential effect on plant operations.
Finding A2-05 Anchorage Behavior	
The long term behavior of anchorages should be guaranteed by a proper aging management program.	SCE conducts structural inspection activities as part of a Nuclear Regulatory Commission (NRC) required maintenance program that includes the periodic review of anchorages for SR equipment.

APPENDIX C - Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications to SONGS**
Anchorage of SR SSCs at the KK nuclear plant performed very well. Specific details and design practice presented by TEPCO will contribute to increasing the seismic safety of anchorages.	The SONGS SR equipment is anchored as required by the SONGS seismic design criteria and will withstand seismic events without loss of function.
Finding A2-06 Basic Integrity Assessment Policy	
Basic policy to assess the integrity of the KK nuclear plant due to an earthquake exceeding the plant's design basis. This basic policy uses a methodology based on the combination of inspections and analyses to determine the integrity of SSCs. The KK nuclear plant inspection plan is recommended to be made available to the nuclear community.	The basic integrity assessment policy provides a comprehensive inspection / evaluation plan for a plant that has experienced seismic ground motions which have exceeded the plant's design basis. The details of the policy are provided in Appendix IV of the IAEA report and are useful to SONGS for the purpose stated above (IAEA, 2009).

APPENDIX C - Assessment of IAEA Findings

IAEA – KK Findings	Discussion of Implications to SONGS
Findings A3-01 Operational Safety Management Response After Shutdown	
The accident management of the event in all units was successfully carried out with respect to the operation of the reactor safety systems. The availability of both operating and safety systems and the existence of applicable accident procedures ensured the safety of the units and demonstrated the strength of maintaining several levels of defenses in depth.	SONGS has an operating instruction for earthquakes and includes specific operator actions, visual inspections, testing, and evaluations. The amount of detailed inspections, testing and evaluations to be performed is dependent on the level of the ground motion recorded at SONGS.
Verification of readiness for operation of the safety systems that were not activated was carried out through visual inspection. It should be carefully analyzed if this procedure is sufficient or if it should be the accepted practice to test with full activation of safety systems without substantial delay after the occurrence of an earthquake.	Not applicable for SONGS since no extreme event has occurred at the site. If a major seismic event were to occur, SONGS has an operating instruction for earthquakes and includes specific operator actions, visual inspections, testing, and evaluations. The amount of detailed inspections, testing and evaluations to be performed is dependent on the level of the ground motion recorded at SONGS.
There was a time delay in reporting the leakage of radioactive material to the authorities. Information from the plant should have been issued more promptly. It is of key importance to report information on releases of radioactive material to the authorities as soon as possible to provide guidance for off-site emergency organizations, even if no significant releases have occurred or are expected to occur as a result of the event.	SONGS emergency planning procedures have specific reporting requirements and schedules for the unintended release of radioactive materials from the plant. In addition, there is a voluntary communication protocol for the Ground Water Protection Initiative which applies to unintended releases. The voluntary communication protocol is made to designated stakeholders and the NRC.

APPENDIX C – Assessment of IAEA Findings	
IAEA – KK Findings	**Discussion of Implications for SONGS**
Finding A3-02 Releases	
Although no releases of radioactive material from the reactor core due to the earthquake were detected, careful attention should be paid to other possible sources of releases, even if the releases are of limited low amounts.	The potential for unmonitored releases of radioactive liquids to the environment was reviewed. SCE evaluated the potential for unintended releases due to equipment leakage or human error. The review included the identification of possible radiological sources, the potential for system leakage, early detection techniques, spill containment features, and mitigation measures. SONGS has taken actions in accordance with the Ground Water Protection Initiative to minimize the potential for an unintended release and to enhance its groundwater protection program.

Appendix 4

Seismic Reliability Study of San Onofre Generating Station Non-Safety-Related Structures, Systems, and Components

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Seismic Reliability Study of San Onofre Nuclear Generating Station Non-Safety Related Structures, Systems, and Components

San Onofre Nuclear Generating Station
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SGH Project 108036

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Engineering of Structures and Building Enclosures

Table of Contents

APPENDICES

1. OBJECTIVE

The objective of this study is to identify important-to-reliability, non-safety-related (NSR) structures, systems, and components (SSCs) at the San Onofre Nuclear Generating Station (SONGS) that could be the cause of a prolonged outage due to a major seismic event. Specifically, the study evaluates NSR SSCs that are required for power generation, including the switchyard, which are, for the purposes of this study, identified as important-to-reliability.

2. PLANT INFORMATION

2.1 Plant Location and Configuration

SONGS consists of two nuclear reactor units, San Onofre Unit 2 and San Onofre Unit 3, which are each capable of generating approximately 1,100 megawatts (MW) of electrical power. Each unit is a separate and independent power plant with no common support equipment required for power generation, with the exception of the site fire protection, carbon dioxide (CO_2) and nitrogen (N_2) supply, and instrument air. The power generation portions of each plant are virtually identical.

SONGS is located along the Pacific coastline south of San Clemente and west of Interstate Highway 5. The plant is located entirely within the boundaries of the U.S. Marine Corps Camp Pendleton Base in northern San Diego County. An aerial view of the site is shown on Figure 2-1. The site was created by excavating the original bluff to remove the terrace deposits and create a level area for the plant on what is known as the San Mateo Sandstone Formation, which consists of very dense sand approximately 900 feet (ft) deep with an average shear wave velocity of approximately 1,900 feet per second (ft/sec) in the top 100 to 150 ft depth. The site soils directly supporting the plant structures were extensively investigated during plant construction and found not to be susceptible to liquefaction. The switchyard is located on a slope that rises to the original bluff level. There are two benches cut into the slope that provide the access roads for the two bus lines that comprise the switchyard. There are offices and shop / storage buildings adjacent to the plant's operational structures. The buildings shown on Figure 2-1, which are east of Interstate 5, are additional offices and warehouse facilities that support the plant's operations.

The SONGS units use ocean water to condense the pressurized steam that has expanded through the turbines and to provide cooling of other plant water systems through heat exchangers. The ocean water for each unit is channeled from offshore intake structures through buried conduit systems to the on-shore intake structure where it is channeled to the circulating water pumps of each unit. The water from each unit is then discharged back to the ocean through separately buried offshore discharge conduits.

SONGS is licensed by the U.S. Nuclear Regulatory Commission (NRC), which issues policies and regulations governing the initial construction, modifications, and operations of nuclear power reactors.

Figure 2-1 Aerial Site View of Both Units

2.2 SONGS Seismic Design Basis

Each of the two units contains safety-related (SR) SSCs and NSR SSCs. The plant's SR SSCs include, but are not limited to, the reactor, nuclear steam supply system (NSSS), containment, and associated emergency equipment. The NRC regulates the design parameters and operation of SR SSCs, which have been designed to allow for the safe-shutdown of a nuclear power plant in the event of a large seismic event, specifically the design-basis earthquake (DBE). The DBE, also known as the safe-shutdown earthquake by the NRC, is associated with an extremely low probability of occurrence.

The SONGS Updated Final Safety Analysis Report (UFSAR), (UFSAR, Current) identifies three categories of SSCs that have specific seismic design criteria.

- **Seismic Category I (SC I).** All SC I SSCs are SR and are, therefore, not evaluated as party of this study[1]. SC I SSCs are designed to remain functional and / or retain structural integrity if a DBE occurs. SC I SSCs must meet the DBE design conditions, as mandated by the NRC and specified in the Code of Federal Regulations (CFR) (10CFR100AppA, Current). The design requirements for SC I SSCs are determined by using a design spectrum shape that has a peak ground acceleration (PGA) value of 0.67g.

[1] SC I SSCs are not evaluated as part of this study (CEC, 2008) because they are designed to withstand a safe-shutdown earthquake without damage.

- **Seismic Category II (SC II).** All SC II SSCs are NSR and were evaluated as part of this study. SONGS SC II SSCs include equipment whose limited damage could interrupt power generation. SC II SSCs, with the exception of the switchyard, were designed to meet an effective static seismic design loading of 0.20g horizontal and 0.13g vertical with no increase factor on allowable stress values. In addition, the design involved verifying that the effective static seismic design loading was not lower than the building code requirements at the time of the design. This was the general seismic design criteria for all Southern California Edison (SCE) power plant structures and equipment anchorage which were in use at the time of plant design.

  The 230 kilovolt (kV) switchyard SSCs were designed to meet the SCE transmission facility effective static seismic design loading of 0.50g horizontal, which was the SCE transmission facility design criterion in use at the time of plant design. This SCE substation design criterion was adopted following the 1971 San Fernando earthquake.

- **Seismic Category III (SC III).** SC III SSCs are NSR SSCs that are not SC I or SC II SSCs but whose failure could inconvenience normal plant operations. Only a few of these SC III SSCs were considered within the scope and evaluated as part of this study. These SSCs were designed to meet the building code requirements at the time of design.

In addition to the three SC categories, there is an additional classification for those SC II SSCs that are located in close proximity to SC I SSCs. These SSCs are required to maintain their structural integrity, including the anchorage at a DBE loading level. This special case of SC II SSCs is denoted as seismic interaction (SI) II/I and is defined as equipment that is not SC I but whose collapse or failure could result in the loss of the safety functions of SC I SSCs.

The design criteria for the plant are viewed as minimum allowable values per the applicable codes and standards that are associated with the SSCs. These standard allowable values have a built-in seismic margin, although there is often a significant seismic margin beyond the built-in margin due to conservatisms that are integrated in the design process.

3. STUDY METHODOLOGY

The following five-phase approach was developed to address the important-to-reliability NSR SSCs.

1) Phase I – Identify important-to-reliability NSR SSCs
2) Phase II – Identify seismic capacity screening criteria
3) Phase III – Determine SONGS review level earthquake
4) Phase IV – Evaluate seismic capacity of important-to-reliability NSR SSCs
5) Phase V – Develop repair / replacement duration estimates and mitigation plans

Figure 3-1 provides an overview of these sequential phases. A similar phased approach is used for NSR buildings that house important-to-reliability SSCs. A different methodology is used for Phase IV to evaluate the capacity of NSR buildings that house important-to-reliability SSCs. This methodology is summarized separately in Section 3.6.

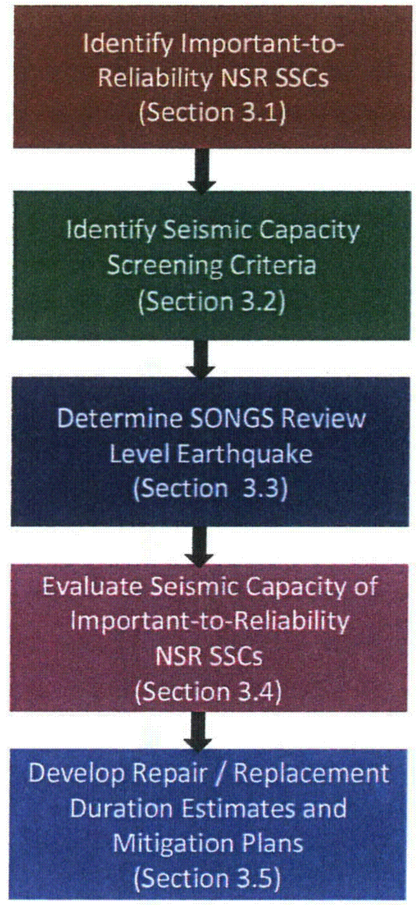

Figure 3-1 Methodology Overview

3.1 Phase I – Identify Important-to-Reliability NSR SSCs

The first phase of this process involves identifying the important-to-reliability NSR SSCs. Figure 3-2 shows the general logic flow that is used to identify the important-to-reliability NSR SSCs. Only NSR SSCs that are required for power generation are included in the final list. The first step involves reviewing the SCE Quality and Classification List (SCE Document No. 90034), which is a list that contains the SSCs at SONGS and their seismic category (SCE, 2009). The next step consists of removing the SSCs in the SCE Quality and Classification List that are outside the scope of this study. First, the SC I SSCs are identified and removed from consideration given that they are outside of the scope. Then, the SSCs not required for power generation are identified and removed from consideration because these SSCs do not impact the power generation reliability. The SSCs remaining on the list constitute the important-to-reliability NSR SSCs (see Appendix B).

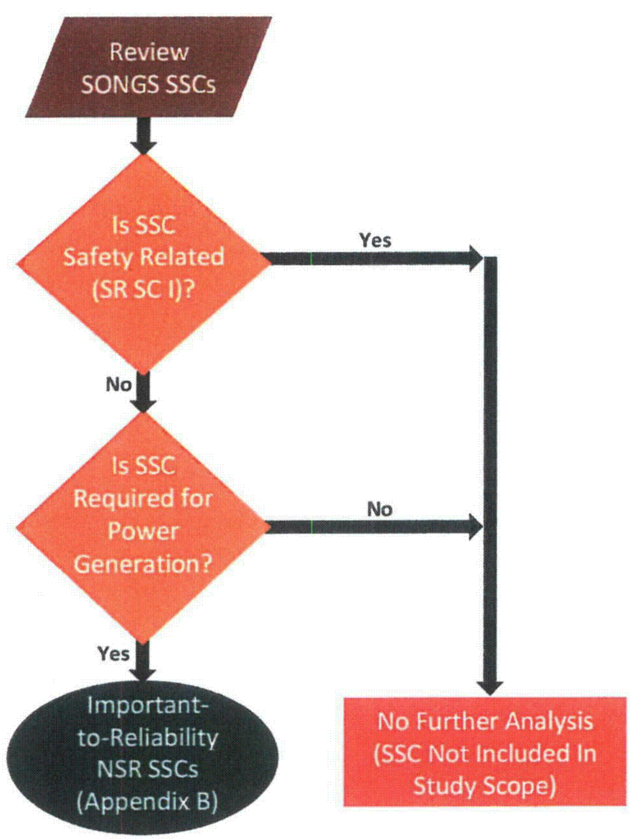

Figure 3-2 Important-to-Reliability NSR SSCs Identification Process

3.2 Phase II – Identify Seismic Capacity Screening Criteria

The next phase involves identifying the seismic capacity screening criteria. NSR SSCs are, at a minimum, designed to meet the building code seismic requirements at the time that they were designed. However, historical earthquake performance has shown that such equipment typically has inherent seismic capacity much greater than the minimum building code seismic requirements. Over the past 20 years, a group known as the Seismic Qualification Utility Group (SQUG)[2] has collected data and documented the results about the performance of various SSCs at large power / industrial plants during and following an earthquake (referred to as earthquake experience data) (SQUG, 1991). SQUG averaged the earthquake response spectra[3] of sites having facilities with representative SSCs that experienced strong ground motion seismic events to determine a ground motion level for which power plant SSCs have survived without damage. This ground motion level is described by a seismic capacity spectrum (referred to as the "reference spectrum" by SQUG). The 5% damping seismic capacity spectrum is characterized by a spectral acceleration level of 1.2g over a frequency range of 2.5 to 7.5 hertz (Hz) and a PGA of 0.5g, which is depicted on Figure 3-3 as the bold line.

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[2] SQUG was formed in the early 1980s to develop a generic methodology to resolve Unresolved Safety Issue (USI) A-46, which was concerned with verifying the seismic adequacy of equipment that was already installed in operating nuclear power plants. Working in conjunction with the regulatory authorities and industry, SQUG developed a methodology and procedure to apply earthquake experience data to demonstrate the seismic capacity of electrical and mechanical equipment for resolution of USI A-46. SQUG developed the "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment" which provided a generic means of applying this experience data to evaluate the seismic adequacy of mechanical equipment, electrical equipment, distributive systems (i.e., ducting, cable trays, conduit, etc.) and passive items (i.e., tanks, heat exchangers, etc.) that are typically part of the balance of plant at a nuclear power plant (SQUG, 1991). The GIP implements this SQUG approach and includes the technical approach, generic procedures, and engineering guidance. The NRC embraced the use of experience-based methods for resolution of USI A-46 in Generic Letter (GL) 87-02, "Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46" (NRC, 1987).

[3] A response spectrum is defined as a plot of the maximum response of an array of single-degree-of-freedom systems of different natural frequencies, each having a damping value expressed as a percentage of critical damping.

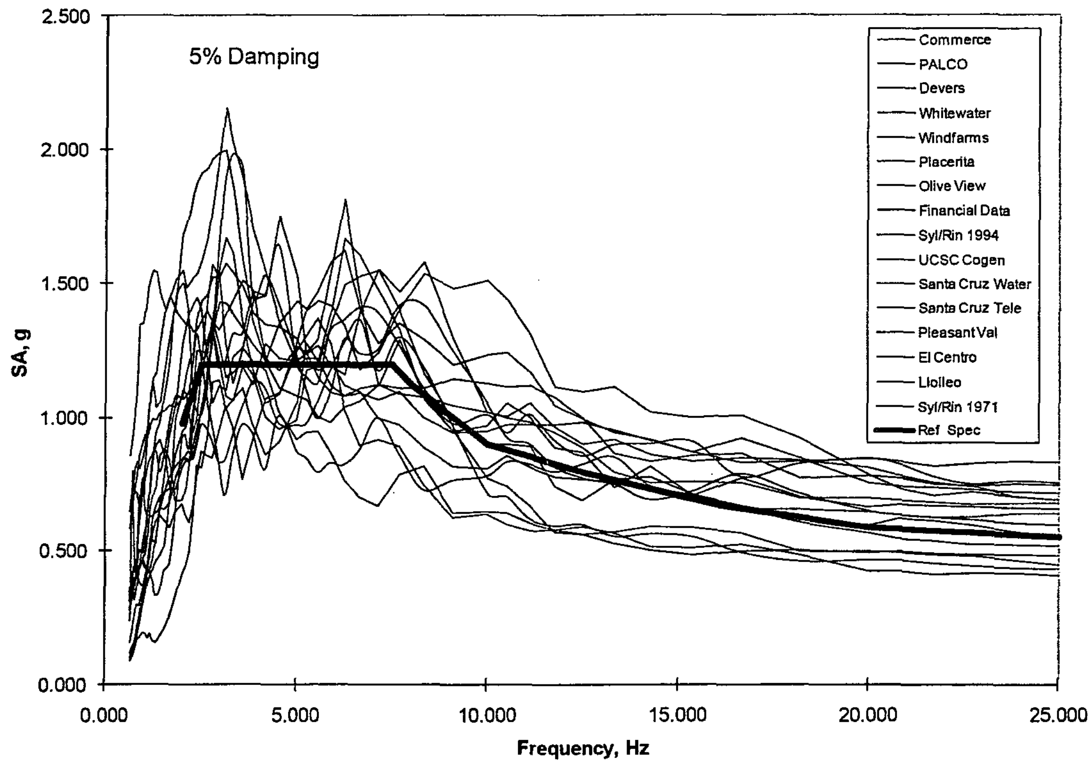

Figure 3-3 Average Horizontal Response Spectra for SQUG Database Sites Compared to the Seismic Capacity Spectrum (also known as the Reference Spectrum)

Based on the number and diversity of SSCs that have survived the motion level represented by the seismic capacity spectrum, this motion level was established as a high confidence of a low probability of failure (HCLPF) (EPRI, 1994, 2002 and 2009). As such, the seismic capacity spectrum does not represent a failure level but rather a level for which there is a high confidence that failure of the SSCs will not occur. The data contained in the SQUG database demonstrate that the actual mean failure level, otherwise known as fragility, is typically at least 2 to 3 times the seismic capacity spectrum (EPRI, 2002 and 2009). This failure margin allows the seismic capacity spectrum to be used as a conservative measure of seismic capacity to screen the important-to-reliability NSR SSCs for the site-specific seismic demand conditions.

3.3 Phase III – Determine SONGS Review Level Earthquake

The seismic capacity spectrum was derived using actual earthquake experience data and represents a conservative measure of seismic capacity for the important-to-reliability NSR SSCs. To understand if this capacity is sufficient to demonstrate adequate reliability for power generation, the seismic demand that is bound by the seismic capacity needs to be determined considering the location and the site-specific conditions at SONGS. Site-specific earthquake ground motion conditions are described by the SONGS probabilistic seismic hazard analysis (PSHA) that was recently updated in 2010 (SCE, 2010).

The SONGS 2010 PSHA determined each spectral acceleration value associated with a given oscillator frequency as a function of annual return period. The annual return period is the number of years it may take for the spectral acceleration value to occur (i.e., a 1,000-year return signifies that the value may occur once in 1,000 years). These sets of functions are denoted as hazard curves. For a given annual return period, a uniform hazard spectrum (UHS) can be plotted to provide the expected spectral content of the motion associated with that annual return period.

The seismic motion that is used for assessing the seismic capacity of the important-to-reliability NSR SSCs is referred as the SONGS review level earthquake. A UHS with a 1,000-year period was chosen for the SONGS review level earthquake. This is a highly unlikely event having an annual probability of exceedance of 0.1%. If SONGS operates through 2042 (assuming that its current license, which expires in 2022, is renewed for an additional 20 years), this motion level corresponds to about a 3.1% probability of occurring over the plant's remaining 31 years of operation.

The SONGS review level earthquake is shown on Figure 3-4. This motion is characterized by a maximum spectral acceleration level of 0.75g at a frequency of 5 Hz and a PGA of 0.32g at 5% damping.

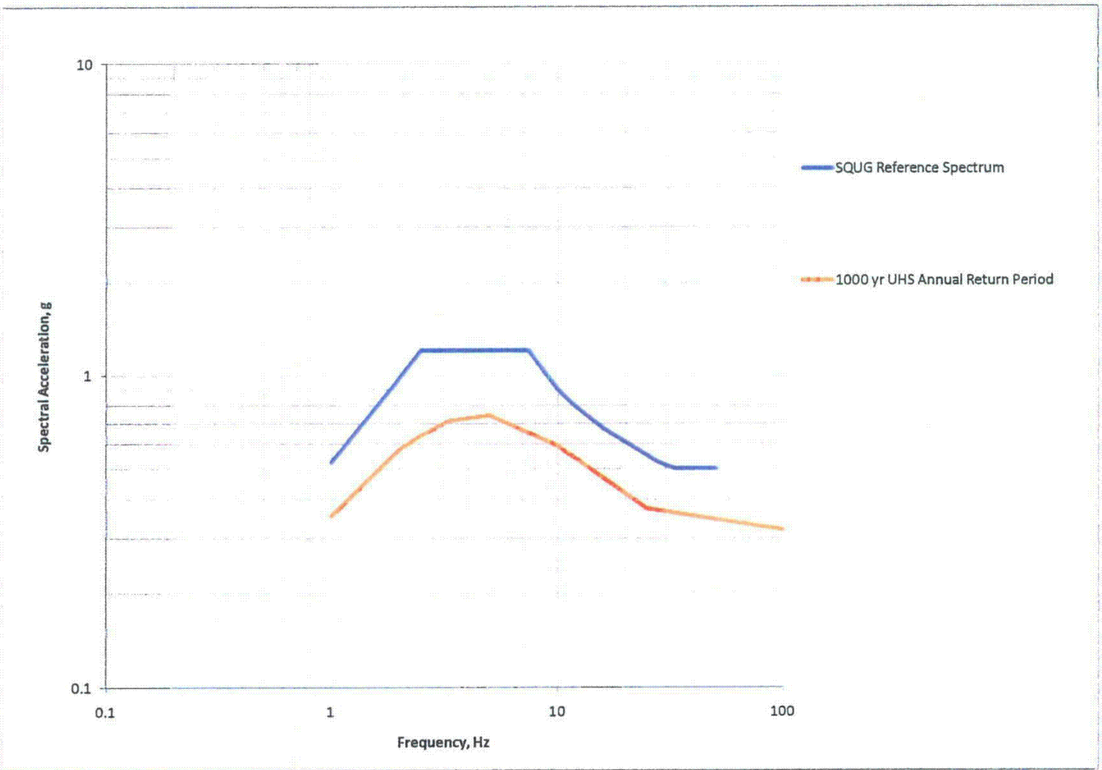

Figure 3-4 Comparison of the Seismic Capacity Spectrum with SONGS Review Level Earthquake (Using a 1,000-Year UHS Annual Return Period)

3.4 Phase IV – Evaluate Seismic Capacity of Important-to-Reliability NSR SSCs

Using the important-to-reliability NSR SSCs list that was generated during Phase I and included in Appendix B, the next phase involves the screening of these SSCs to determine the important-to-reliability NSR SSCs that have a seismic capacity greater than the SONGS review level earthquake.

The seismic capacity screening is accomplished by reviewing plant design documents, conducting walkdowns, and using the SQUG database. Three specific criteria are used in the seismic capacity screening:

- Anchorage
- Spatial Interaction
- Functionality

SI II/I SSCs are screened only for the spatial interaction and functionality criteria given that their anchorages were already designed to the DBE loading. Figure 3-5 shows the general logic flow used to accomplish the screening.

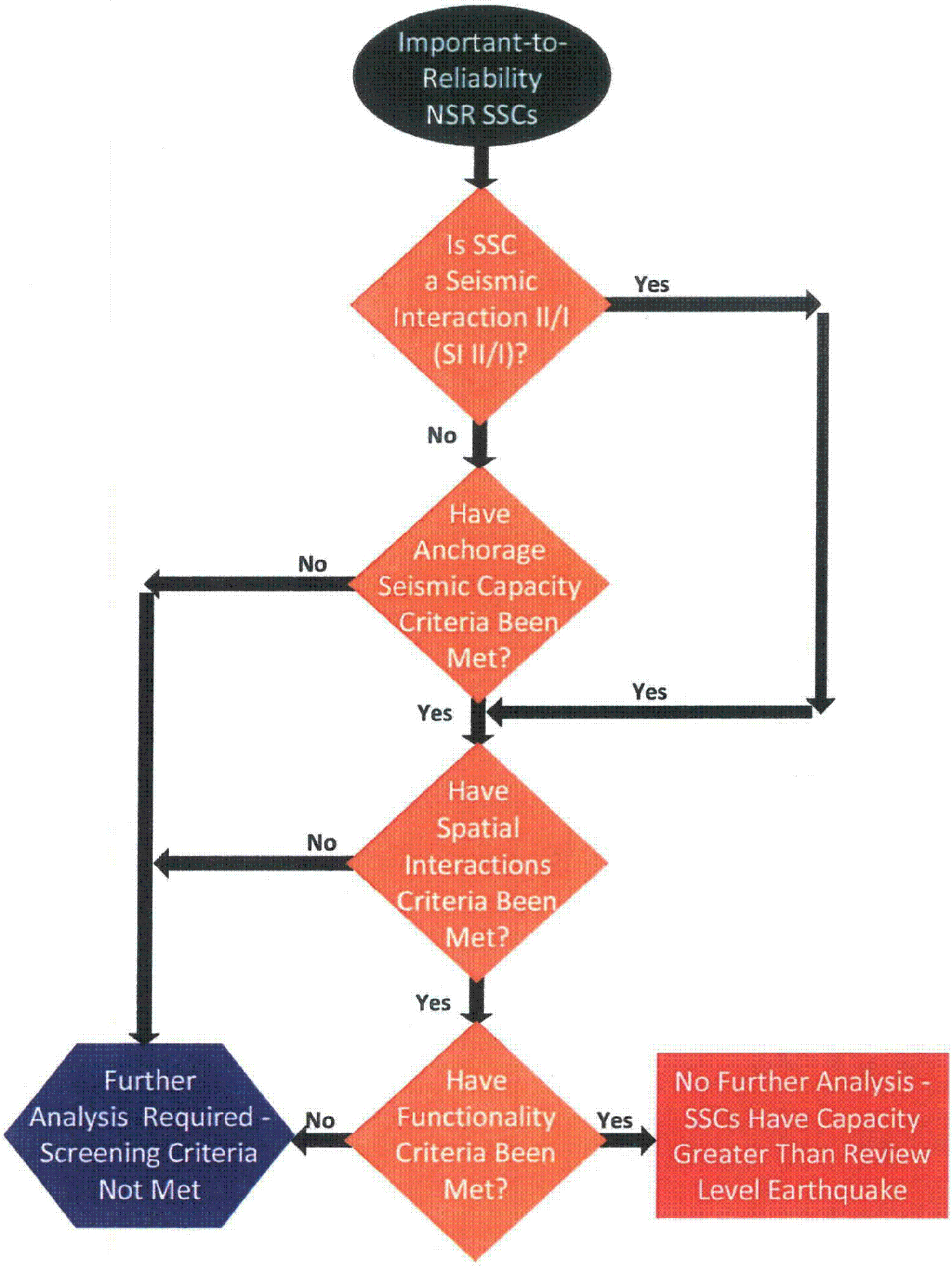

Figure 3-5 Seismic Capacity Screening Process

The anchorage seismic capacity screening involves verifying that the anchorage can withstand a SONGS review level earthquake. In performing the anchorage evaluation, the plant's existing documentation, including drawings, specifications, calculations, and typical details are reviewed. In addition, the anchorage is visually inspected during a walkdown to check for adequate installation and to determine if the anchorage load path is sufficient. Specifically, the strength of the equipment is assessed to verify that it is able to effectively transfer the loads to the anchorage. Base isolation systems for equipment must also be evaluated for seismic adequacy.

The spatial interactions screening involves performing the following interaction evaluations:

- Proximity – Determine the impact from adjacent equipment due to relative motion.
- Structural failure and falling – Determine the impact from the failure of overhead and adjacent equipment, structures, or architectural features.
- Flexibility – Determine the impact of attached lines due to relative displacements.

The functionality screening involves determining if the candidate SSC is similar to SSCs in the existing seismic experience database. This screening consists of examining the design documentation (e.g., specifications and drawings) to determine similarity to the actual SSCs contained in the seismic experience SQUG database. If the SQUG seismic experience database does not include similar SSCs, a specific evaluation is performed.

SSCs whose seismic capacity is greater than the SONGS review level earthquake (i.e., SSCs that demonstrate no seismic vulnerabilities at the SONGS review level earthquake level) are screened out, and no further analysis is required. For those SSCs that are not screened out, a more rigorous evaluation of seismic capacity is necessary. A fragility evaluation is conducted to determine the probable failure modes of the SSC. If the SSC seismic capacity is shown to be higher than the SONGS review level earthquake, then no further evaluation is needed. If the SSC seismic capacity is shown to be lower than the SONGS review level earthquake, then this SSC is added to the subset of SSCs that require repair / duration estimates. Figure 3-6 shows the general logic flow used for this further seismic evaluation.

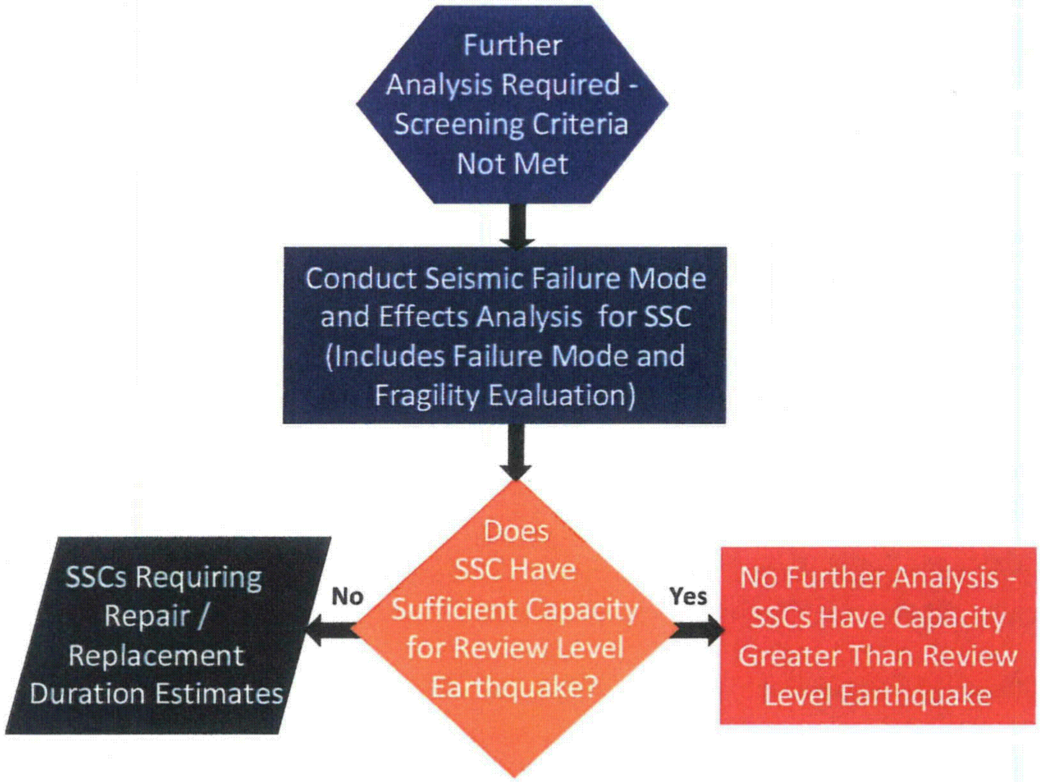

Figure 3-6 Further Seismic Evaluation Process

3.5 Phase V – Develop Repair / Replacement Duration Estimates and Mitigation Plans

Having established the probable failure modes and likely extent of damage to those SSCs that do not have seismic capacity equivalent to the SONGS review level earthquake, the next phase is to determine the conceptual level repair / replacement time duration estimates for those SSCs. The repair / replacement time duration estimates are evaluated to determine whether they represent the possibility of a prolonged outage following a major seismic event. For any SSCs identified as requiring a prolonged outage under those circumstances, mitigation plans are developed by SCE. The general logic flow used for this final phase is shown on Figure 3-7.

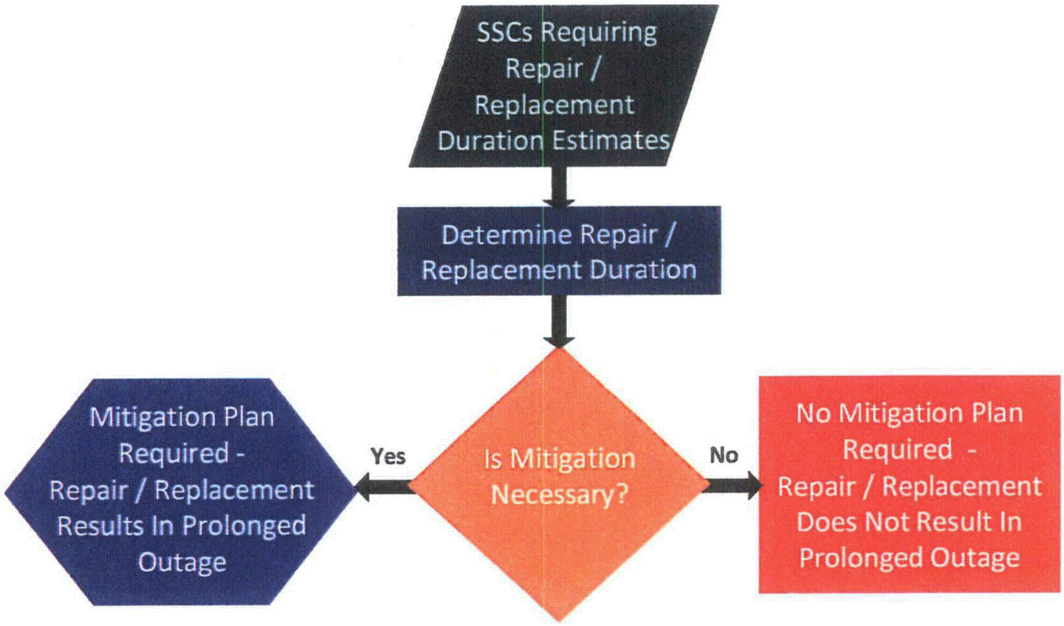

Figure 3-7 Repair / Replacement Duration Estimate and Mitigation Plan Development Process

3.6 Screening Process for NSR Buildings that House Important-to-Reliability SSCs

This seismic capacity screening process described in Section 3.4 is not applicable for NSR buildings that house important-to-reliability NSR SSCs. Instead, a commonly accepted methodology developed by the Federal Emergency Management Agency (FEMA) (FEMA, 2000, 2006) is used. This methodology is used by design professionals to assess building safety following earthquakes and is contained in national consensus software designated as HAZards United States (HAZUS). Within the HAZUS methodology are seismic capacity functions for different model building types that can be used to assess the risk of earthquake damage to these traditional commercial structures. Using the HAZUS methodology, the capacity can be estimated for the selected NSR buildings that house important-to-reliability NSR SSCs, considering the acceptable damage state and type of construction. These procedures are discussed in detail in Appendix E.

4. RELIABILITY STUDY RESULTS

4.1 SONGS Important-to-Reliability NSR SSCs

Using the five-phase methodology described in Section 3.0, important-to-reliability NSR SSCs were identified. An initial list, provided in Appendix B, of important-to-reliability NSR SSCs was generated following a review of SCE's Quality and Classification List. However, this equipment classification list could not be used to complete seismic capacity evaluation because it only considered general component types within a system and did not specify the individual component identification and location. Separate lists were prepared for the electrical equipment (see Appendix C) and the mechanical equipment (See Appendix D). These lists provide the identification and location of each specific important-to-reliability NSR SSC. In addition, Table 4-1 lists the plant's systems associated with power generation that were identified during this process. In order to prepare these lists, plant system documentation and the process and instrumentation diagrams (P&ID) or one-line electrical drawings were reviewed to identify specific components.

The primary SSCs associated with power generation are housed in the turbine building, the main steam isolation valve (MSIV) area, the control area of the auxiliary building, the tank building, and the intake structure. Additional SSCs used for the distribution of the generated power are located in the plant yard. While the turbine buildings were classified as SC II, the turbine buildings are designed for SI II/I to resist the DBE loading. Additionally, while the mechanical, electrical, and distribution system components housed within the turbine buildings were classified as SC II, their anchorages would be able to resist DBE loading. This was confirmed by a walkdown and review of plant design documentation.

Table 4-1 Plant Systems Associated with Power Generation

Steam and Power Conversion Systems • Steam System • Feedwater and Condensate Systems • Turbine Lube System • Condenser Air Removal System • Main Condenser System • Generator Seal Oil System • Electro Hydraulic Oil System
Balance-of-Plant Water Systems • Circulating Water System • Turbine Plant Cooling Water System • Main Generator Cooling System • Demineralized Water Systems
HVAC Systems • Control Area-Auxiliary Building • Turbine Building
Electrical Systems • 22,000 V AC System • 6,900 V AC System • 4,160 V AC System • 480 V System • DC System • AC Control Power System • Lighting System • Excitation System • 230 kV Switchyard
Fire Protection System
Auxiliary Systems • Instrument Air System • N_2 Gas Supply System • H_2 Gas Supply System

Explanation:

1. V = volts
2. AC = alternating current
3. DC = direct current
4. N_2 = nitrogen
5. H_2 = hydrogen

There are only two non-power block NSR buildings – the SCE switchyard relay building and the San Diego Gas & Electric (SDG&E) switchyard relay building – that house operational important-to-reliability NSR SSCs. Both are separate single-story buildings that house relay racks. In addition, the Mesa warehouse is a NSR building that houses spare parts that can be used for repairing important-to-reliability NSR SSCs. These spare parts may be needed to repair the NSR SSCs that may sustain damage during a major seismic event.

The list of NSR buildings selected for evaluation is shown in Table 4-2.

Table 4-2 SONGS NSR Buildings Selected for Evaluation

Mesa Warehouse - Pre-engineered Steel Structure
Switchyard Relay Houses - Reinforced Masonry
• SCE – Single-Story Separate Building • SDG&E – Single-Story Separate Building

4.2 Capacity Evaluation Results

The equipment lists provided in Appendices C and D were used to perform the walkdown of the SONGS important-to-reliability NSR SSCs required for power generation as part of the seismic capacity evaluation. The walkdown was conducted by qualified seismic capability engineers who were certified as having successfully completed the SQUG training course[4] on seismic evaluation methods and who met the requisite education and engineering experience requirements. Since Units 2 and 3 are virtually identical in layout and components, Unit 2 was selected for the walkdown.

Within the SONGS plant's systems, some SSCs were identified as requiring a more rigorous analysis. The more rigorous analysis involved conducting a detailed seismic capacity evaluation that identified failure modes and fragilities. The NSR building structures identified as important-to-reliability were also evaluated using the HAZUS procedures and screened against the SONGS review level earthquake.

The SSCs were categorized as 1) having seismic capacity greater than the SONGS review level earthquake, 2) having seismic capacity less than the SONGS review level earthquake, or 3) requiring further review. A discussion of each of these categories is provided in the following sections.

[4] SQUG offers training courses to help users properly apply the various guidelines and tools developed by SQUG. This training is needed since the criteria and guidelines in the GIP included new methods and approaches as compared to the traditional methods for seismic qualification of equipment.

4.2.1 SSCs with Seismic Capacity Greater Than the SONGS Review Level Earthquake

The majority of the important-to-reliability NSR SSCs were determined to have a seismic capacity greater than the SONGS review level earthquake. A discussion is provided below for select power generation components.

4.2.1.1 Turbine / Generator Support Systems

The turbine / generator are the primary components for power generation. The primary mechanical support systems necessary to ensure turbine function are the steam / reheat system, the feedwater / condensate system including the condensate and feedwater pumps, the circulating water system, the condenser, the turbine plant cooling system, the lube oil system, the seal oil system, the stator cooling water system, and the hydrogen cooling system. These systems comprise pumps, valves, and the associated piping distribution systems. The primary electrical power support systems necessary to ensure turbine function are the medium voltage AC power system, the low voltage AC power systems, the DC power systems, and the associated cable tray and conduit distribution systems. The mechanical and electrical systems are controlled by various control interfaces and instrumentation systems, and associated wiring and cable distribution systems. The bulk of these components are housed within the turbine building of each unit and the auxiliary building with other components housed within the respective MSIV areas and tank buildings of each unit. The turbine building is mainly an open structure that has only local fans to promote air movement. The auxiliary building and portions of the turbine buildings have heating, ventilation, and air conditioning (HVAC) systems and the associated distribution ducts for air movement and heat removal. The important-to-reliability NSR SSCs of these mechanical, electrical, control / instrumentation, and HVAC support systems are of a similar type and configuration as non-nuclear power plant SSCs and are therefore similar to those found in SQUG's seismic experience database. The important-to-reliability NSR SSCs within these buildings were found to have anchorages able to withstand the DBE. Additionally, they were determined to be similar to the SSCs that performed well during and after an earthquake, based on earthquake experience. Thus, these SSCs were found to have a capacity greater than the SONGS review level earthquake.

4.2.1.2 Turbine / Generator

The rotating turbine shaft is supported and rides on 11 journal bearings, and longitudinal movements of the shaft are prevented using a single Kingsbury-type thrust bearing. These bearings use high oil pressure maintained by the lube oil system to prevent excessive movement of the shaft and metal-to-metal contact at the bearings. The Kingsbury-type of thrust bearing is designed to sustain very high thrust loads and remain functional.

The turbine / generator were considered to be special components requiring a more in-depth review. In general, turbo-machinery has high seismic capacity, and the earthquake experience with turbine generators is good. For an operating turbine, the most common issue has been associated with the loss of lube oil pressure during turbine coast-down caused by the loss of offsite power following an earthquake. The SSCs that comprise the turbine / generator coast-down lube oil system must maintain the necessary oil pressure required for the journal and thrust bearing to function during turbine / generator coast-down following the trip of a unit. If any disruption of the oil supply and pressure occurs during the coast-down period, then the journal and / or thrust bearings could be damaged. This type of failure mode, however, is associated with the design of the lube oil system and not the turbine / generator itself. The SONGS lube oil and seal oil systems were recently upgraded with redundant pumps and battery-backed power sources to prevent this failure mode from occurring. These components are anchored for the DBE loading, and their functionality will not be impacted after a SONGS review level earthquake event.

Except for a few isolated cases, earthquake damage to turbine components has otherwise not occurred. In one case, turbine / generator alignment was disturbed by the shifting of alignment shims during an aftershock. The SONGS turbine generator is not aligned in this manner.

It is important to note that a nuclear plant turbine is larger and operates at lower temperatures and pressures than a fossil-fired plant turbine. Until recently, the earthquake experience with larger nuclear plant turbines was limited. However, the turbine generators for the nuclear units at the Kashiwazaki-Kariwa Nuclear Power Plant were disassembled and inspected following the offshore magnitude 6.8 Niigataken-Chuetsu-Oki (NCO) earthquake that occurred near the plant in 2007. Four of the turbine generators were in operation at the time the earthquake occurred. While contact marks were found on the bearing surfaces, no issues that would have prevented turbine operation following the earthquake were discovered. The thrust bearings for the turbines were not the Kingsbury-type like those found at SONGS, but rather simple parallel plane-type bearings, which are not as rugged. Minor contact marks were found on the turbine bearing surface of all of the units, even those that had not been in operation during the earthquake. This suggests that the contact marks on the bearing surfaces were not earthquake-caused, but rather occurred during normal operation and start-up procedures. Some partially fractured turbine blades were also found in two of the units. However, these fractures were concluded to not be earthquake-related, but rather due to the over-speed test of the turbines during the initial unit start-up period. The plant's units had been operating with the partially fractured blades prior to the earthquake. This experience suggests that nuclear turbines have substantial seismic capacity and that functional performance following an earthquake is limited by the support system components and not the turbine generator itself. Consequently, the seismic capacity of the turbine generator exceeds the SONGS review level earthquake.

4.2.1.3 Offshore Intake Conduit and Main Intake Structure

The buried offshore intake conduit is SC I, with the exception of the segment from the auxiliary intake structure to the main offshore intake structure, which is SC II. However, the SC II segment of the offshore intake conduit has the same design as the SC I segment. In addition, controlled gravel that is not susceptible to liquefaction was used as backfill material for the entire length of the conduit. As a result, offshore intake conduits were determined as having a seismic capacity greater than SONGS review level earthquake.

The offshore intake structure, although SC II, was designed to withstand DBE loading and therefore has a seismic capacity greater than the SONGS review level earthquake.

4.2.1.4 Switchyard Relay Houses

There are two one-story relay houses located in the SONGS switchyard that contain relay racks. The relay racks were determined as having a capacity greater than the SONGS review level earthquake. These two buildings were evaluated with the HAZUS procedure, and the results indicated that they were likely to sustain moderate damage following a SONGS review level earthquake. This would result in the building being green tagged, which would allow continued unrestricted entry and access to the structure.

4.2.1.5 Spare Parts for Important-to-Reliability SSCs Stored in the Mesa Warehouse Building

The 100,000 square foot (sq. ft) warehouse is located in the Mesa area east of Interstate 5. The warehouse stores spare parts that may be required for repairing the transformer and switchyard important-to-reliability NSR SSCs. These spare parts are generally packed in crates and are stored either on the ground or on the lower shelves of the storage racks. The racks in the Mesa warehouse building are anchored to the concrete slab and are braced. Additionally, the racks have adequate moment connections between the horizontal members of the shelves and the rack legs. Although the racks may sustain moderate deformations and distortions during a SONGS review level earthquake, the access to and retrieval of the items stored on the shelves will not be difficult. However, some of the items, mainly those located on the top shelves, may slide or fall off the shelves during an earthquake. These would likely fall into the aisles between the racks, but would not impact the items that are stored on the lower shelves in the racks. Thus the damage to the stored spare parts required for repairing important-to-reliability NSR SSCs would be limited following a SONGS review level earthquake. The building was evaluated using the HAZUS methodology, and the results indicated that it would sustain extensive damage following a SONGS review level earthquake yet allow for access to the building contents. However, any debris that results from the extensive damage would come from the light roof elements. This debris would not affect the spare parts since they are crated and stored within the racks at ground level or on lower shelves.

4.2.2 SSCs with Seismic Capacity Less Than the SONGS Review Level Earthquake

The walkdown and the subsequent detailed analyses identified the following SSCs as having capacities below the SONGS review level earthquake:

- Main, Auxiliary, and Reserve Auxiliary Transformers
- Line Dead End Towers, Downcomers, and Switches
- Transmission Breakaway Towers
- Makeup Demineralized Water Tanks

For each of the important-to-reliability NSR SSCs above, a detailed analysis was conducted to identify the probable failure modes and the likely extent of damage that might be sustained during a SONGS review level earthquake. Table 4-3 provides a summary of the failure modes identified for each SSC.

Table 4-3 Components that Have Capacities Below SONGS Review Level Earthquake

Component	Location	Failure Mode
Main, Unit Auxiliary, and Reserve Auxiliary Transformers		
Main Transformer	Yard	Anchorage Failure
Main Transformer Phase Bus	Yard	Expansion Joint Boot Damage
Main Transformer 230 kV Bushings	Yard - Main Transformers	Shifting of Porcelain
Main Transformer Surge Arresters	Yard - Main Transformers	Porcelain Failure
Main Transformer Radiator Headers	Yard - Main Transformers	Gasket Joint Failure
Unit Auxiliary Transformers	Yard	Anchorage Failure
Reserve Auxiliary Transformers	Yard	Anchorage Failure
Reserve Auxiliary Transformers 230 kV Bushings	Yard – Reserve Auxiliary Transformers	Shifting of Porcelain
Reserve Auxiliary Transformer Surge Arresters	Yard - Reserve Auxiliary Transformers	Porcelain Failure
Reserve Auxiliary Transformers Radiator Headers	Yard - Reserve Auxiliary and Unit Auxiliary Transformers	Gasket Joint Failure
Line Dead End Towers, Downcomers, and Switches		
Line Dead End Towers	Switchyard	Base Plate Connection Weld Cracking
Downcomers	Switchyard	Tether Post Anchorage Failure
Disconnect Switches	Switchyard	Switch Misalignment and Base Bearing Deformation
Transmission Breakaway Towers		
Main Transformer - Transmission Breakaway Tower	Yard - Main Transformers	Base Plate Connection Weld Cracking
Reserve Auxiliary Transformers - Transmission Breakaway Tower	Yard – Reserve Auxiliary Transformers	Base Plate Connection Weld Cracking
Tall Pedestal Mounted Disconnect Switches	Yard – Reserve Auxiliary Transformer	Switch Misalignment, Base Bearing Deformation, and Porcelain Failure
Makeup Demineralized Water Tanks		
Makeup Demineralized Water Tanks	South Tank Area	Base Uplift and Shell Buckling

4.2.2.1 Main, Auxiliary, and Reserve Auxiliary Transformers

The output of the 22 kV generators is routed to the main transformer of each unit using phase bus structures that were designed using the 0.2g NSR seismic design criterion. Earthquake joints were incorporated in the phase bus design, but the sealing boots are expected to pull apart in an earthquake. Because the phase bus is air cooled, the loss of the joint seals will reduce the current capacity in the phase bus until it is repaired.

The anchorage of the main transformers was also designed for the 0.2g NSR seismic design criterion. An analysis of the anchorage load path using American Concrete Institute (ACI) 349 criteria indicates that the anchorage capacity is below the SONGS review level earthquake. The supports of the conservator tank mounted on the main transformer are judged to be vulnerable at the same earthquake level.

A similar anchorage analysis was performed for the smaller auxiliary transformers and the reserve auxiliary transformers, and results indicated that the anchorage capacities of the transformers are less than the SONGS review level earthquake.

Past earthquake experience indicates that the transformer oil radiator piping has the potential to leak. In addition, the transformer bushings may shift and the mounted surge arresters may fail. Fragility data compiled by California utilities (Eidinger, et al, 1995) indicate that capacities are below the SONGS review level earthquake.

The disconnect switches supported on the tall pedestal frames adjacent to the reserve auxiliary transformers may also become misaligned. In addition, the base bearings may deform and the porcelain may become damaged.

4.2.2.2 Line Dead End Towers, Downcomers, and Switches (Switchyard) and Transmission Breakaway Towers (Yard)

In the SONGS switchyard, the 0.5g SCE transmission facility (1975) seismic design criterion was utilized for the anchorage of the power apparatus and design of the support structures.

The SONGS line dead end towers, as well as the transmission getaway towers located in the plant yard adjacent to the transformers, use the same configuration and fabricated tube type that was extensively damaged in the 1994 Northridge earthquake at the SCE Pardee Substation, which was designed at approximately the same time as SONGS. The Pardee dead end towers experienced two basic failure modes: 1) the flexibility of the towers contributed to the lateral displacement of the suspended potential transformers (PTs) incorporated in the conductor downcomers that resulted in the failure of the downcomer post supports and also caused damage to the adjacent disconnect switches; and 2) weld cracking that occurred in the base plate connection of the tower tubular sections. The weld failures were similar to the unanticipated brittle weld fractures that occurred in many building connections subjected to the 1994 Northridge earthquake. The cause of such weld cracking was determined to not be a design issue but rather the result of fabrication issues, such as the lack of control of base metal properties, the use of weld filler materials with low toughness, and the lack of proper preheat and welding procedures (FEMA, 2000). The towers were designed for 0.5g loading; however, the tower base connection weld detail had a unique configuration (i.e., a full penetration weld of a tubular structural member to a very thick base plate) which produced welds that were susceptible to brittle cracking. This unique configuration was only specific to the tower base welded connections and was not present in any other location at SONGS. Furthermore, the rest of the tower structure behaved as expected in conformance with the design. The Pardee towers were still functional following the Northridge earthquake but required re-welding of the base details and the addition of gusset plates to the base plate connections. The measured ground motion at the Pardee substation was used to provide the basis for the capacity evaluation of the line dead end towers, the transmission breakaway towers, the conductor downcomers and suspended PTs, and the adjacent disconnect switches.

4.2.2.3 Makeup Demineralized Water Tanks

The makeup demineralized water tanks consist of unanchored 535,000 gallon tanks that were designed in accordance with the American Petroleum Institute (API) Standard 620 seismic design criteria. These types of tanks have historically been damaged due to base uplift and shell buckling that would ultimately lead to a loss of contents.

4.2.3 SSCs Requiring Additional Analysis for Seismic Capacity Assessment

4.2.3.1 Offshore Discharge Conduits

The offshore discharge conduits were identified as potentially unable to withstand the SONGS review level earthquake; thus, a detailed analysis is required. Some of the backfill used for the discharge conduits was sand. Thus, soil liquefaction of the backfill is possible during an earthquake, which could cause the discharge conduits to become buoyant and come apart at the joints. A detailed analysis is in progress to evaluate the capacity of the offshore discharge conduits to withstand a SONGS review level earthquake.

4.3 Repair and Replacement Duration Estimates

Table 4-4 of this study presents conceptual repair / replacement time duration estimates to restore function of the important-to-reliability NSR SSCs that may sustain damage during a SONGS review level earthquake. Procurement, design, and construction times were evaluated and provided by SCE. The conceptual repair / replacement time duration estimates assumed the following:

- Only one unit is required to be put back to service following a SONGS review level earthquake as the SCE transmission system is designed to operate reliably with one SONGS unit out-of-service.

- When groups of common SSCs were considered, they were assumed to have a 50% failure rate. Based on the recovery efforts for power system damage caused by prior earthquakes (Eidinger, et al, 1995), a failure rate of 40 to 50% for a 230 kV substation power apparatus has been observed for ground motion levels having PGA values within the range 0.4 to 0.5g. Thus, a 50% failure rate is an upper bound estimate for earthquake damage to yard and switchyard equipment due to a SONGS review level earthquake.

- The other unit can be a source for replacement parts, which may eliminate the need of procurement for some parts that have a long lead time.

Table 4-4 Conceptual Repair and Replacement Estimates

Repair / Replacement Area	Component	Estimated Time to Restore Function (Months)
Plant Yard Electrical Components	Main, Unit Auxiliary, and Reserve Auxiliary Transformer • Phase Bus • 230 kV Bushings • Surge Arresters • Radiator Headers • Anchorages	≤ 3
	Transmission Breakaway Towers • Tower Bases • Tall Pedestal Mounted Disconnect Switches	
Switchyard Components	Line Dead End Towers Base Plates	≤ 3
	Downcomers	
	Disconnect Switches	
Makeup Demineralized Water Tanks	-	≤ 4

4.3.1 Plant Yard Electrical Components

The scope of work to repair / replace the plant yard electrical components includes:

- Repair of 50% of the transformer anchorages (including anchor bolt replacements, concrete repairs, and weld repairs).
- Replacement of 50% of the transformer bushings and arresters.
- Repair of 50% of the transformer radiator oil piping supporting the radiators.
- Repair of the conservator tank supports.
- Repair of 50% of the isophase joints (the outer casing joints will need to be resealed).
- Repair of 50% of the breakaway transmission tower base plate connections.

This work is estimated to take 3 months.

4.3.2 Switchyard Components

The scope of work to repair / replace the switchyard components includes:

- Repair of the base plate weld connection on 50% of the dead end transmission towers.
- Repair of 50% of the downcomer tethers.
- Replacement of 50% of the disconnect switch bases.

This work is estimated to take 3 months.

4.3.3 Makeup Demineralized Water Tanks

There are three 535,000 gallon makeup demineralized water tanks that, if damaged during an earthquake, will require replacement. The scope of this work includes:

- Demolition.
- Removal of the existing tanks.
- Installation of a new foundation.
- Supply and installation of new tanks.
- Replacement of the connection pipes.

A complete replacement of the tanks is estimated to take 4 months.

4.4 Mitigation Plans

The initial repair / replacement estimates have not identified any component that could cause a prolonged outage due to a seismic event. Therefore, mitigation plans were not developed.

5. CONCLUSIONS

This study has not identified any important-to-reliability NSR SSCs that could be the cause of a prolonged outage due to a seismic event. The offshore discharge conduits are currently undergoing further specialized evaluations (soil laboratory testing and time history soil structure interaction analyses) to assess their seismic capacity.

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Appendix A
List of Acronyms

AC	Alternating Current
ACI	American Concrete Institute
AEBM	Advanced Engineering Building Module
AISC	American Institute of Steel Construction
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
CEC	California Energy Commission
CBC	California Building Code
CFR	Code of Federal Regulations
CMAA	Construction Management Association of America
CO_2	Carbon Dioxide
DBE	Design-Basis Earthquake
DC	Direct Current
UFSAR	Updated Final Safety Analysis Report
EPRI	Electric Power Research Institute
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
ft	Feet
ft/sec	Feet per Second
GIP	Generic Implementation Procedure
GL	Generic Letter
H_2	Hydrogen
HAZUS	HAZards United States
HCLPF	High Confidence of Low Probability of Failure
HEI	Heat Exchange Institute
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
in.	Inch
kV	Kilovolts
kVA	Kilovolts-Amperes
MSIV	Main Steam Isolation Valves

MW	Megawatts
N_2	Nitrogen
NCO	Niigataken-Chuetsu-Oki
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSR	Non-Safety-Related
NSSS	Nuclear Steam Supply System
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
o.c.	On Center
P&ID	Process and Instrumentation
PGA	Peak Ground Acceleration
PSHA	Probabilistic Seismic Hazard Analysis
PT	Potential Transformer
SCE	Southern California Edison
SC I	Seismic Category I
SC II	Seismic Category II
SC III	Seismic Category III
SDG&E	San Diego Gas & Electric
SI II/I	Seismic Interaction II/I
SMACNA	Sheet Metal and Air Conditional Contractors' National Association
SONGS	San Onofre Nuclear Generating Station
sq. ft	Square Foot
SQUG	Seismic Qualification Utility Group
SR	Safety-Related
SSCs	Structures, Systems, and Components
UBC	Uniform Building Code
UFSAR	Updated Final Safety Analysis Report
UHS	Uniform Hazard Spectrum
USI	Unresolved Safety Issue
UL	Underwriters Laboratory
V	Volts

Appendix B
Equipment Classification List

Equipment Classification

UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
1.2.6.3	***Lightning Protection***					
	Lightning rods, associated cables and fasteners	U.L. 96A,NFPA 78	II	C	Out	Does not affect power generation[4]
2.4 & 2.5	**HYDROLOGIC ENGINEERING/GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING (SITE-RELATED HAZARDS AND PROTECTION)**					
2.4.5.5	***Seawall***	ACI 318	II	O	Out	Does not affect power generation[4]
2.5.6	***PROBABLE MAXIMUM FLOOD (PMF) BERM AND CHANNEL***		II	M/O	Out	Does not affect power generation[4]
3.2	**CLASSIFICATION OF STRUCTURES, COMPONENTS, AND SYSTEMS**					
	Consumables (including lubricants/greases) not important to the functional capacity and performance of SR SSCs		II,III	All	Out	Readily replaced
3.4.1	***FLOOD PROTECTION***					
3.4.1.1	***Waterstops, bellows***	—	II[3]	All	Out	Designed for II/I[5]; Does not affect power generation[4]
	SEISMIC CATEGORY I STRUCTURES					
3.8.3	***CONTAINMENT INTERNAL STRUCTURES***					
	Jib Crane	CMAA	II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
4	**REACTOR**					
4.2	**REACTOR FUEL SYSTEM**					
	Neutron source	None	II	C	Out	Does not affect power generation[4]
5	**REACTOR COOLANT SYSTEM (RCS) AND CONNECTED SYSTEMS**					
5.4.1	***REACTOR COOLANT PUMPS (RCPS)***					
	Motors	NEMA MG-1	II[3]	C	In	Designed for II/I[5]
	Operating and backup oil lift pumps		II[3]	C	In	Designed for II/I[5]
	Operating and backup oil lift pump motors		II[3]	C	In	Designed for II/I[5]
	Operating and backup anti-reverse rotation device (ARRD) pumps		II[3]	C	In	Designed for II/I[5]
	Operating and backup ARRD pump motors		II[3]	C	In	Designed for II/I[5]
	RCP seal heat exchangers					
	CCW side	B31.1	II	C	In	Internal design of heat exchanger - unit anchored for II/I[5]
	Motor heat exchangers		II[3]	C	In	Designed for II/I[5]
5.4.10	***PRESSURIZER***					
	Heaters and cables	III-1	I, II	C	Out	Internal subcomponents of Category I component
5.4.11	***PRESSURIZER RELIEF DISCHARGE SYSTEM***					
	Quench tank	VIII	II[3]	C	In	Designed for II/I[5]
	Piping					
	Downstream of safety valve	B31.1	II	C	In	
	Valves associated with quench tank	B31.1	II	C	In	
6	**ENGINEERED SAFETY FEATURES**					
6.3	**SAFETY INJECTION SYSTEM**					
	Piping and valves					

Equipment Classification						
UFSAR Section	**Principal Component**	**Principal Design and Construction Code or Standard[1]**	**Seismic Category**	**Location[2]**	**In/Out of Scope**	**Comment**
	Drain lines	B31.1	II	C	Out	Does not affect power generation[4]
6.5	**FISSION PRODUCT REMOVAL AND CONTROL SYSTEMS**					
	Iodine removal system					
	Tank	III-2	II[3]	S	Out	Designed for II/I[5]; System deactivated
	Piping and valves	III-2	II[3]	C/S	Out	Designed for II/I[5]; System deactivated
	Supports	ASME	II[3]	C	Out	Designed for II/I[5]; System deactivated
7	**INSTRUMENTATION AND CONTROL SYSTEMS**					
7.5	**SR DISPLAY INSTRUMENTATION**					
7.5.1.6	***Control element assembly position indication***	IEEE 279	II	A/C	Out	Does not affect power generation[4]
7.6	**ALL OTHER INSTRUMENTATION SYSTEMS REQUIRED FOR SAFETY(Z)**					
7.6.1.7	***Anticipated Transient Without Scram (ATWS) System***					
	Diverse Scram System (DSS) Cabinet and Cabling		II[3]	A/C/P	Out	Designed for II/I[5]; Does not affect power generation[4]
	Diverse Turbine Trip (DTT) Cabling		II	A	Out	Does not affect power generation[4]
	Diverse Emergency Feedwater Actuation System (DEFAS) Cabinet and Cabling		II[3]	A/C	Out	Designed for II/I[5]; Does not affect power generation[4]
7.6.1.10	***Data Acquisition System (DAS)***		II	A	Out	Does not affect power generation[4]
7.7	**CONTROL SYSTEMS NOT REQUIRED FOR SAFETY**					
7.7.1.1.1	Boron control system		II	A/C	Out	Does not affect power generation[4]
7.7.1.2.1	Pressurizer pressure control system		II	A/C	Out	Does not affect power generation[4]
7.7.1.2.2	Pressurizer level control system		II	A/C	Out	Does not affect power generation[4]
7.7.1.3	***Feedwater control system***		II	A/C/T/ MSIV	In	
7.7.1.4	***Steam bypass control system***		II	A/C/T	In	
7.7.1.7	***In-core instrumentation system***		II	A/C	Out	Does not affect power generation[4]
7.7.1.8	***Ex-core instrumentation system (startup and control channels)***		II	A/C	Out	Does not affect power generation[4]
7.7.1.10	***Drain Down Level Monitoring System (DLMS)***					
	Cable and incontainment junction boxes		II[3]	A/C/P	Out	Designed for II/I[5]; Does not affect power generation[4]
7.7.3.1	***Refueling Water Level Instrument (RWLI)***					
	Transmitters		II	C	Out	Does not affect power generation[4]
	Indicators		II[3]	A	Out	Designed for II/I[5]; Does not affect power generation[4]
8	**ELECTRIC POWER SYSTEMS**					
8.2	**OFFSITE POWER SYSTEM**					
	Main transformers	ANSI C57.12	II	O	In	
	Auxiliary transformers	ANSI C57.12	II	O	In	
	Reserve auxiliary transformers	ANSI C57.12	II	O	In	
	220 kV disconnect switches	ANSI C57.30	II	O	In	
	Electrical equipment (220 kV switchyard)		II	O	In	

Equipment Classification						
UFSAR Section	**Principal Component**	**Principal Design and Construction Code or Standard[1]**	**Seismic Category**	**Location[2]**	**In/Out of Scope**	**Comment**
8.3	**ONSITE POWER SYSTEMS**					
8.3.1	***AC POWER SYSTEMS***					
	Non-class 1E equipment		II, II[3]	All	In	Designed for II/I[5]
8.3.2	***DC POWER SYSTEMS***					
	Non-class 1E equipment		II, II[3]	All	In	Designed for II/I[5]
9	**AUXILIARY SYSTEMS**					
9.1.3	***SPENT FUEL POOL COOLING AND CLEANUP SYSTEM***					
	Pumps					
	Makeup and purification pumps		II	F	Out	Does not affect power generation[4]
	Pump motors					
	Makeup and purification pump motors		II	F	Out	Does not affect power generation[4]
	Piping and valves					
	Purification subsystem					
	Other	B31.1	II	C/F/P	Out	Does not affect power generation[4]
	Makeup subsystem (backup)	B31.1	II	F/O/TK	Out	Does not affect power generation[4]
	Other					
	Ion-exchangers	VIII	II	F	Out	Does not affect power generation[4]
	Filters and strainers	VIII	II	F	Out	Does not affect power generation[4]
9.1.4	***FUEL HANDLING SYSTEM***					
	Refueling machine including auxiliary hoist	CMAA/AISC	II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Spent fuel handling machine	CMAA/AISC	II[3]	F	Out	Designed for II/I[5]; Does not affect power generation[4]
	Control element assembly change machine	AISC	II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Fuel transfer equipment set	CMAA/AISC	II	F/C	Out	Does not affect power generation[4]
	Reactor vessel head lifting rig		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Reactor internals lifting rig		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Refueling pool seal assembly		II	C	Out	Does not affect power generation[4]
	Containment polar crane	CMAA	II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Mechanical Operation					
	Bridge structure		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Trolley		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Main hoist and auxiliary hoist		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Main hoist and auxiliary hoist brakes		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Electrical Control					
	DC Power/PLC		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Trolley drive and brakes		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Bridge drive and brakes		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Main hoist and auxiliary hoist drives		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Rotate drive (main hook)		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Limit switches and resolvers		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]

Equipment Classification						
UFSAR Section	**Principal Component**	**Principal Design and Construction Code or Standard[1]**	**Seismic Category**	**Location[2]**	**In/Out of Scope**	**Comment**
	Platforms and Jib Hoist		II[3]	C	Out	Designed for II/I[5]; Does not affect power generation[4]
	Cask handling crane	CMAA	II[3]	F	Out	Designed for II/I[5]; Does not affect power generation[4]
	New fuel elevator	CMAA/AISC	II[3]	F	Out	Designed for II/I[5]; Does not affect power generation[4]
	New fuel crane	CMAA	II[3]	F	Out	Designed for II/I[5]; Does not affect power generation[4]
9.2.3	***DEMINERALIZED WATER MAKEUP SYSTEM***					
	Demineralized water storage system	API 620	II	O	In	
9.2.5	***ULTIMATE HEAT SINK***					
	Main offshore intake structure	ACI 318	II[3]	O	In	Per UFSAR designed to withstand DBE
	Intake conduit					
	From one pipe section beyond auxiliary intake structure to main offshore intake structure	ACI 318	II[3]	O	In	Per UFSAR designed to withstand DBE
	Outfall conduit					
	West end box conduit seaward		II	O	In	
9.2.6	***CONDENSATE STORAGE FACILITY***					
	Portion associated with turbine plant					
	Condensate storage tank 2(3)T-120	API 650	II	TK	In	
	Pumps		II	O	In	
	Piping and valves	B31.1	II	O	In	
9.2.7	***NUCLEAR SERVICE WATER SYSTEM***					
	Storage tank	API 620	II	Y	In	
	Pumps and motors	HI/NEMA MG-1	II	Y	In	
	Piping and valves					
	Other	B31.1	II	A/C/F/P/S/Y	In	
9.2.8	***TURBINE PLANT COOLING WATER SYSTEM***					
	Tanks	API 620	II	O	In	
	Pumps and motors		II	O	In	
	Piping and valves	B31.1	II	T/O	In	
	Heat exchangers	VIII	II	O	In	
	Filters		II	T/O	In	
9.3.1	***COMPRESSED AIR SYSTEM***					
	Receivers	VIII	II	T	In	
	Compressors	VIII	II	T	In	
	Piping and valves					
	Other	B31.1	II	All	In	
	Aftercoolers	VIII	II	T	In	
	Dryers	VIII	II	T	In	
	Filters	VIII	II	T	In	
9.3.2	***PROCESS SAMPLING SYSTEMS***					
	Nuclear plant sampling system					

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
	Sample vessels	VIII	II	A	Out	Does not affect power generation[4]
	Sample blowers	VIII	II	A	Out	Does not affect power generation[4]
	Piping and valves					
	Coolant chemical and volume control system sample lines	III-2	II	A	Out	Does not affect power generation[4]
	Volume control tank sample lines up through the first normally shut valve	III-2	II	A	Out	Does not affect power generation[4]
	Waste gas system sample lines	B31.1	II	A	Out	Does not affect power generation[4]
	Other	B31.1	II	C/P/A	Out	Does not affect power generation[4]
	Coolers	VIII	II	A	Out	Does not affect power generation[4]
	Filters	VIII	II	A	Out	Does not affect power generation[4]
	Turbine plant sampling system coolers	VIII	II	A	Out	Does not affect power generation[4]
9.3.3	***EQUIPMENT AND FLOOR DRAINAGE SYSTEM***					
	Nonradioactive sump and drain systems					
	Piping and valves/pumps					
	Auxiliary building	UPC	II, III	A	Out	Does not affect power generation[4]
	Diesel generator building	UPC	II	D	Out	Does not affect power generation[4]
	East and west turbine plant area	UPC	II, III	T	Out	Does not affect power generation[4]
	North Industrial Area	UPC	II, III	Y	Out	Does not affect power generation[4]
	Radioactive sump and drain systems					
	Piping and valves/pumps					
	Component cooling water	B31.1	II	S	Out	Does not affect power generation[4]
	Containment area	B31.1	II	C	Out	Does not affect power generation[4]
	Fuel handling building	B31.1	II	F	Out	Does not affect power generation[4]
	Penetration area	B31.1	II	P	Out	Does not affect power generation[4]
	Safety injection area	B31.1	II	S	Out	Does not affect power generation[4]
	Storage tank area	B31.1	II	TK	Out	Does not affect power generation[4]
	Radwaste area	B31.1	II	A	Out	Does not affect power generation[4]
	Liner plate for safety equipment building sumps, fuel handling building sump, penetration area sump, and radwaste area sump	AISC/ASME	II	A/F/P/S	Out	Does not affect power generation[4]
9.3.4	***CHEMICAL AND VOLUME CONTROL SYSTEM***					
	Tanks					
	Volume control tank	III-2	II	A	In	
	Pumps					
	Primary plant makeup pumps		II	A	In	Needed to make power in reactor
	Motors					
	Primary plant makeup pump motors		II	A	In	Needed to make power in reactor
	Piping and valves					

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
	Letdown portion (from letdown backpressure control valve to radwaste diversion valve)	III-2	II	A	In	
	Volume control tank (between isolation valves)	III-2	II	A	In	
	Letdown heat exchanger					
	Purification ion-exchanger	III-2	II	A	In	
	Delithiating ion-exchanger	III-2	II	A	In	
	Deborating ion-exchanger	III-2	II	A	Out	Not required for power operation
	Purification filter	III-2	II	A	In	
9.4.1	***CONTAINMENT BUILDING VENTILATION SYSTEMS***					
9.4.1.1	***Normal Operation--Containment Building Ventilation Systems***					
	Containment normal cooling units					
	Air handling units	ARI/AMCA	II	C	In	
	Ductwork and dampers	SMACNA	II[3]	C	In	Designed for II/I[5]
	Chillers	ARI	II	A	In	
	Chilled water pumps		II	A	In	
	Compression tanks	ASME Section VIII	II	A	In	
	Piping and valves					
	Other (inside containment)	B31.1	II[3]	C	In	Designed for II/I[5]
	Other (outside containment)	B31.1	II	P/A	In	
	Strainers		II	A	In	
	Purge recirculation cleanup system					
	Purge supply units	AMCA	II	A	Out	Does not affect power generation[4]
	Purge exhaust units	AMCA	II	A	Out	Does not affect power generation[4]
	Recirculation cleanup unit (HEPA filters)	HSI-306/MIL-F-51068C	II	C	Out	Does not affect power generation[4]
	Ductwork and dampers					
	Other	ORNL-65/SMACNA	II[3]	C/P/A	Out	Designed for II/I[5]; Does not affect power generation[4]
	CEDM cooling system					
	Cooling coils		II	C	In	
	Fans and motors	AMCA	II	C	In	
	Ductwork and dampers	SMACNA	II[3]	C	In	Designed for II/I[5]
	Reactor cavity cooling system					
	Fans and motors	AMCA	II	C	In	
	Ductwork and dampers	SMACNA	II[3]	C	In	Designed for II/I[5]
	MSIV enclosure and penetration area cooling system					
	Supply fans	AMCA	II	MSIV	In	Only need penetration fans, not penetration area cooling.
	Exhaust fans	AMCA	II	MSIV	Out	Does not affect power generation[4]
	Duct work and dampers	SMACNA	II	MSIV	In	
9.4.1.2	***Emergency Operation--Containment Building Ventilation Systems***					

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
	Hydrogen purge supply and exhaust units					
	Prefilters		II[3]	P	Out	Designed for II/I[5]; Does not affect power generation[4]
	HEPA filters	HSI-306/MIL-F-51068C	II[3]	P	Out	Designed for II/I[5]; Does not affect power generation[4]
	Charcoal filters	CS-8T	II[3]	P	Out	Designed for II/I[5]; Does not affect power generation[4]
	Electric heating coils		II	P	Out	Does not affect power generation[4]
	Fans and motors	AMCA	II	P	Out	Does not affect power generation[4]
	Ductwork					
	Other	ORNL-65/SMACNA	II[3]	C/P	Out	Designed for II/I[5]; Does not affect power generation[4]
	Valves					
	Other	B31.1	II	P	Out	Does not affect power generation[4]
	Dome air circulating units					
9.4.2	***AUXILIARY BUILDING VENTILATION SYSTEMS***					
9.4.2.1	***Normal Operation–Auxiliary Building Ventilation Systems***					
	Control room system					
	Air handling units	AMCA/ARI	II	A	In	
	Fan coil units	AMCA/ARI	II	A	In	
	Control room smoke removal fan	AMCA/NFPA	II	A	Out	Does not affect power generation[4]
	Electric duct heaters		II	A	In	
	Exhaust fans	AMCA	II	A	In	
	Transfer fans	AMCA	II	A	In	
	Ductwork and dampers	SMACNA	I, II[3]	A	In	Designed for II/I[5]
	Radwaste area system					
	Air handling units	AMCA	II	A	Out	Does not affect power generation[4]
	Exhaust fans	AMCA	II	A	Out	Does not affect power generation[4]
	CEDMCS room fan coil units		II	A	In	
	Electric duct heaters		II	A	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	A	Out	Does not affect power generation[4]
	ESF switchgear room systems					
	Air handling units	AMCA/ARI	II	A	In	
	Exhaust fans	AMCA	II	A	In	
	Electric duct heaters		II	A	In	
	Ductwork and dampers	SMACNA	II	A	In	
	Cable spreading and electrical room systems					
	Air handling units	AMCA	II	A	Out	Does not affect power generation[4]
	Return fans	AMCA	II	A	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	A	Out	Does not affect power generation[4]
	Chiller room systems					
	Air handling unit	AMCA	II	A	In	
	Exhaust fan	AMCA	II	A	In	

Equipment Classification						
UFSAR Section	**Principal Component**	**Principal Design and Construction Code or Standard**[1]	**Seismic Category**	**Location**[2]	**In/Out of Scope**	**Comment**
	Electric duct heater		II	A	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	A	In	
	Battery room systems					
	Air handling unit	AMCA	II	A	In	
	Exhaust fan	AMCA	II	A	In	
	Ductwork and dampers	SMACNA	II	A	In	
	Continuous exhaust system					
	Fans	AMCA	II	A	In	Need at least 1 of these 3 fans
	Ductwork and dampers	SMACNA	II	A/O	In	
	Plant vent stacks		II[3]	O	In	Designed for II/I[5]
9.4.3	***SUPPORT BUILDING VENTILATION SYSTEMS***					
9.4.3.1	***Fuel Handling Building Ventilation System***					
	Normal supply and exhaust system					
	Prefilters		II	F	Out	Does not affect power generation[4]
	Fans and motors	AMCA	II	F	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	F	Out	Does not affect power generation[4]
9.4.3.2	***Safety Equipment Building Ventilation System***					
	Pump room normal cooling systems					
	Fan coil units	AMCA/ARI	II	S	Out	Can operate with only Emergency Room coolers
	Heat exchanger room normal cooling systems					
	Fan coil units	AMCA/ARI	II	S	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	S	Out	Does not affect power generation[4]
	Air conditioning equipment room normal cooling system					
	Fan coil units	AMCA/ARI	II	S	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	S	Out	Does not affect power generation[4]
	Lobby area air conditioning system					
	Fan coil units	AMCA/ARI	II	S	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	S	Out	Does not affect power generation[4]
	Electric duct heaters		II	S	Out	Does not affect power generation[4]
9.4.3.3	***Turbine Building Ventilation System***					
	Steam air ejector exhaust system					
	Exhaust filtration unit	HSI-306/MIL-F-51068C	II	T	Out	Don't require to operate
	Piping and valves	ANSI B31.1	II	T	In	
	Main generator isophase bus connection enclosure ventilation system					
	Exhaust fans and motors		III	T	In	The Iso-Phase Bus has a current rating of 36.3 kA with forced cooling provided, and 21.2 kA if self-cooled.
	Ductwork	SMACNA	III	T	In	
	D7 Battery and Battery Charger Rooms (El. 56')					

Equipment Classification						
UFSAR Section	**Principal Component**	**Principal Design and Construction Code or Standard[1]**	**Seismic Category**	**Location[2]**	**In/Out of Scope**	**Comment**
	Supply Air Units	AMCA	II	T	In	
	Exhaust fans and motors	AMCA	II	T	In	
	Ductwork and dampers	SMACNA	II	T	In	
	Electric duct heaters		II	T	In	
9.4.3.4	***Diesel Generator Building Ventilation System***					
	Normal ventilation system					
	Fans and motors	AMCA	II	D	Out	Does not affect power generation[4]
	Ductwork	SMACNA	II	D	Out	Does not affect power generation[4]
9.4.3.5	***Penetration Building and Electric and Piping Tunnels Ventilation System***					
	Penetration building system					
	Air conditioning and ventilation supply units	AMCA/ARI	II	P	Out	Does not affect power generation[4]
	Prefilters		II	P	Out	Does not affect power generation[4]
	Transfer fans	AMCA	II	P	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	P	Out	Does not affect power generation[4]
	Electric and piping tunnel system					
	Ventilation supply units	AMCA	II	All	Out	Does not affect power generation[4]
	Exhaust fans	AMCA	II	All	Out	Does not affect power generation[4]
	Ductwork and dampers	SMACNA	II	All	Out	Does not affect power generation[4]
9.4.3.7	***Auxiliary Feedwater Pump Room Ventilation System***					
	Normal heating and ventilation system					
	Electrical unit heater		II	TK	Out	Does not affect power generation[4]
9.4.3.8	***Safety Equipment Building Elevator Machine Room and Condensate Storage Tank Area Ventilation System***					
	Safety Equipment Building Elevator Machine Room Ventilation System					
	Exhaust fan	AMCA	II	S	Out	Does not affect power generation[4]
	Condensate Storage Tank Area Ventilation System					
	Electrical unit heater		II	TK	Out	Does not affect power generation[4]
9.5.1	***FIRE PROTECTION SYSTEM***					
	Water System					
	Tanks	NFPA/API 650	II	O	In	Required by the Technical Specifications
	Pumps and motors	NFPA/NMR	II	O	In	
	Piping and valves					
	Suppression system	NFPA	II	All	In	
	Gaseous system (Halon)	NFPA/VIII	II	A	In	Not needed to start
	Gaseous system (CO_2)					
	Other	NFPA	II	T/O	In	Not needed to start
	Fire Barrier					
	Rated doors, walls	ACI-318, NFPA	II, III	A/C/D/F/MS IV/S/T/TK	Out	Does not affect power generation[4]

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard(1)	Seismic Category	Location(2)	In/Out of Scope	Comment
	Penetration seals	ASTM E119	II,III	A/C/D/F/MS IV/S/T/TK	Out	Does not affect power generation(4)
	Fire resistant wrap	NFPA/ASTM E119	II(3)	A/C/D/F/S/T /TK	Out	Designed for II/I(5); Does not affect power generation(4)
	Conduits and cable trays		I, II(3)	All	Out	Designed for II/I(5); Does not affect power generation(4)
	Fire dampers	NFPA	II, III	A/C/D/F/S/T /TK	Out	Does not affect power generation(4)
	Fluid diversion structure (RCP lube oil collection system)	ANSI B31.1, ASME VIII, and AISC	II	C	Out	Designed for II/I(5); Does not affect power generation(4)
9.5.2	***COMMUNICATIONS SYSTEM***					
	Reservoir Thunderbolt Siren	FCC	II	O	Out	Does not affect power generation(4)
9.5.3	***LIGHTING SYSTEMS***					
	Lighting components integral to control room ceiling		II(3)	A	Out	Designed for II/I(5); Does not affect power generation(4)
	Control room emergency lights		II(3)	A	Out	Designed for II/I(5); Does not affect power generation(4)
	8-hour emergency lights	UL924, IES	II/III	All	Out	Does not affect power generation(4)
9.5.6	***DIESEL GENERATOR STARTING AIR SYSTEM***					
	Compressors		II	D	Out	Does not affect power generation(4)
	Air dryers		II	D	Out	Does not affect power generation(4)
	Filters, intake		II	D	Out	Does not affect power generation(4)
10	**STEAM AND POWER CONVERSION SYSTEM**					
10.2	**TURBINE-GENERATOR**					
	Turbine: High, low pressure		II	T	In	
	Control and protective valve system	B31.1	II	T	In	
	Turbine drains	B31.1	II	T	In	
	Exhaust hood spray system	B31.1	II	T	In	
	Lube oil system					
	Components	VIII	II	T	In	
	Turbine control system		II	T	In	Per high pressure and low pressure valve
	Turbine control panel		II	T	In	
	Turbine supervisory system		II	T	In	
	Turbine protective devices		II	T	In	
	Turbine overspeed protection	IEEE 279	II	A/T	In	
	Turbine monitoring equipment		II	T	In	
	Turbine support accessories		II	T	In	
	Generator		II	T	In	
	Seal oil system	VIII	II	T	In	
	Hydrogen coolers	VIII	II	T	In	
	Generator H_2/CO_2 system		II	T	In	
	Stator water system	VIII	II	T	In	

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
	Exciter switchgear and voltage regulator		II	T	In	
	Exciter		II	T	In	
	Piping and valves	B31.1	II		In	
	Turbine gantry crane	CMAA	II	T/O	Out	Does not affect power generation[4]
10.3	**MAIN STEAM SUPPLY SYSTEM**					
	Steam traps		II	S/T/TK	Out	Does not affect power generation[4]
	Reheaters	VIII	II	T	In	
	Moisture separator-reheater drain tanks	VIII	II	T	In	
	Main steam tube bundle drain tanks	VIII	II	T	In	
	Bled steam tube bundle drain tanks	VIII	II	T	In	
	Y-strainers	VIII	II	T	In	
	Piping and valves					
	Other	B31.1	II	MSIV/T	In	
10.4.1	***MAIN CONDENSER***					
	Main condensers	HEI	II	T	In	
	Vent and drain system	B31.1	II	T	In	
	Piping and valves	B31.1	II	T	In	
10.4.2	***MAIN CONDENSER EVACUATION SYSTEM***					
	Seal water heat exchanger	VIII/HEI	II	T	In	
	Air ejector condenser	VIII	II	T	In	
	Air ejectors	VIII/HEI	II	T	In	
	Condenser vacuum pump	VIII	II	T	In	
	Seal water pumps		II	T	In	
	Separator tanks		II	T	In	
10.4.3	***TURBINE GLAND SEALING SYSTEM***					
	Gland steam condenser exhaust fan		II	T	In	
	Gland steam condenser	VIII	II	T	In	
	Piping and valves	B31.1	II	T	In	
10.4.4	***TURBINE BYPASS SYSTEM***					
	Piping and valves	B31.1	II	T	In	
10.4.5	***CIRCULATING WATER SYSTEM***					
	Pumps and motors		II	IN	In	
	Piping and valves	B31.1	II	IN	In	
	Expansion joints		II	IN	In	
	Strainers	VIII	II	IN	In	
	Traveling rakes and bar screens		II	IN	In	
	Gates #4, 5, and 6		II[3]	IN	In	Designed for II/I[5]
	Gate operators and accessory equipment		II[3]	IN	In	Designed for II/I[5]
10.4.6	***CONDENSATE CLEANUP SYSTEM (FULL FLOW CONDENSATE POLISHING DEMINERALIZER)***					

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
	Seal water heat exchangers	VIII	II	FFCPD	Out	Does not affect power generation[4]
	Tanks	VIII	II	FFCPD/O	Out	Does not affect power generation[4]
	Pumps		II	FFCPD/O	Out	Does not affect power generation[4]
	Polishers					
	Fines filter		II	FFCPD	Out	Does not affect power generation[4]
	Sample coolers		II	O	Out	Does not affect power generation[4]
	Air blower package		II	FFCPD	Out	Does not affect power generation[4]
	Resin hopper		II	FFCPD	Out	Does not affect power generation[4]
	Piping and valves	ANSI B31.1	II	FFCPD/O	Out	Does not affect power generation[4]
10.4.7	***CONDENSATE AND FEEDWATER SYSTEM (ALSO REFER TO CONDENSATE STORAGE SYSTEM, SUBSECTION 9.2.6)***					
	Tanks					
	Heater drain tanks	VIII	II	T	In	
	Feedwater pump seal drain tanks	VIII	II	T	In	
	Feedwater pump turbine drain tanks	VIII	II	T	In	
	Pumps and motors					
	Condensate transfer pumps		II	T	In	
	Condensate pumps		II	T	In	
	Heater drain pumps		II	T	In	
	Feedwater pumps		II	T	In	
	Feedwater pump turbine drain pumps		II	T	In	
	Piping and valves					
	Other	B31.1	II	T	In	
	Feedwater heaters	VIII	II	T	In	
10.4.8	***STEAM GENERATOR BLOWDOWN SYSTEM***					
	Tanks					
	Blowdown flash tank	VIII	II	T	Out	Can bypass tank
	Demineralizer acid storage tanks	VIII	II	T	Out	Not used
	Demineralizer caustic storage tanks	VIII	II	T	Out	Not used
	Pumps and motors					
	Acid metering pumps	VIII	II	T	Out	Not used
	Caustic metering pumps	VIII	II	T	Out	Not used
	Piping and valves					
	Other	B31.1	II	MSIV/T	In	
	Blowdown heat exchanger	VIII	II	T	In	
	Demineralizer hot water heat exchanger	VIII	II	T	Out	Not used
	Mixed bed demineralizers	VIII	II	T	Out	Not used
10.4.10	***TURBINE PLANT CHEMICAL ADDITION SYSTEM***					
	Pumps and motors					
	Amine feed pumps		II	T	In	

Equipment Classification						
UFSAR Section	Principal Component	Principal Design and Construction Code or Standard[1]	Seismic Category	Location[2]	In/Out of Scope	Comment
	Piping and valves	B31.1	II	T	In	
11	RADIOACTIVE WASTE MANAGEMENT SYSTEMS					
11.2	LIQUID WASTE MANAGEMENT SYSTEM (COOLANT RADWASTE, MISCELLANEOUS LIQUID WASTE, AND BORIC ACID RECYCLE SYSTEMS)					
	Tanks, atmospheric (except primary plant makeup storage tank)	API 650	II	A	Out	Does not affect power generation[4]
	Tanks, pressure	VIII	II	C	Out	Does not affect power generation[4]
	Pumps and motors		II	A	Out	Does not affect power generation[4]
	Piping and valves					
	Other	B31.1	II	A/C/P	Out	Does not affect power generation[4]
	Ion-exchangers	VIII	II	A	Out	Does not affect power generation[4]
	Filters and strainers	VIII	II	A	Out	Does not affect power generation[4]
	Tank heaters	NEMA 4	II	A	Out	Does not affect power generation[4]
	Gas strippers	VIII	II	A	Out	Does not affect power generation[4]
	Evaporators					
	Process and cooling water side	III-3	II	A	Out	Does not affect power generation[4]
	Steam side	VIII	II	A	Out	Does not affect power generation[4]
11.3	GASEOUS WASTE MANAGEMENT SYSTEM (WASTE GAS SYSTEM)					
	Tanks					
	Surge tank	VIII	II	A	Out	Does not affect power generation[4]
	Decay tanks	VIII	II	A	Out	Does not affect power generation[4]
	Pumps and motors					
	Surge tank drain pump		II	A	Out	Does not affect power generation[4]
	Compressor assembly					
	Compressor	VIII	II	A	Out	Does not affect power generation[4]
	Motor		II[3]	A	Out	Designed for II/I[5]; Does not affect power generation[4]
	Piping and valves					
	Waste gas surge tank drain	B31.1	II	A	Out	Does not affect power generation[4]
	Waste gas discharge header	B31.1	II	A	Out	Does not affect power generation[4]
	Vent gas collection header	B31.1	II	A	Out	Does not affect power generation[4]
	Other	B31.1	II	A/C/P	Out	Does not affect power generation[4]
	Y-strainer	VIII	II	A	Out	Does not affect power generation[4]
11.5	PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLE SYSTEMS					
	All other airborne radiation monitors		II	A/T	Out	Does not affect power generation[4]
	Liquid radiation monitors	VIII	II	A/P/T/Y	Out	Does not affect power generation[4]
	Sample piping and tubing	B31.1	II	T	Out	Does not affect power generation[4]
	Normal sample lab isolation monitor	IEEE 279/323/338/383	II	A	Out	Does not affect power generation[4]
12	RADIATION PROTECTION					
12.3	AREA RADIATION MONITORING SYSTEM					
	Area radiation monitors		II	A/C/F/S	Out	Does not affect power generation[4]

Explanation:

1. Principal Design and Construction Code or Standard includes: ACI = America Concrete Institute, AISC = American Institute of Steel Construction, AMCA = Air Movement and Control Association, ANSI = American National Standards Institute, ASME = American Society of Mechanical Engineers, CMAA = Construction Management Association of America, FCC = Federal Communications Commission, HEI = Heat Exchange Institute, IEEE = Institute of Electrical and Electronics Engineers, IES = Illuminating Engineering Society, ORNL = Oak Ridge National Laboratory, NEMA = National Electrical Manufacturers Association, NFPA = National Fire Protection Association, SMACNA = Sheet Metal and Air Conditional Contractors' National Association, and U.L. = Underwriters Laboratory,
2. *The location was assigned to one of the following categories: A = Auxiliary Building, C = Containment Building, D = Diesel Generator Building, F = Fuel Handling Building, FFCPD =* Full Flow Condensate Polishing Demineralizer Area, IN = Intake Structure, MSIV = Main Steam Isolation Valve Area, O = Outdoor Yard Area, P = Penetration Area, S = Safety Equipment Building, T = Turbine Building, TK = Tank Building
3. Signifies that the Category II component is anchored for the DBE loading to prevent interaction with Category I components.
4. Signifies that the Category II component may be need to be functional during power operation but does not affect power generation capability and is easily replaceable / repairable.
5. II/I = seismic interaction II/I

Appendix C
Electrical Equipment List

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2XM	Main Transformer	Power Transformer 22 kV/220 kV	Anchorage Capacity	Yard	No	No	Yes
	Surge Arrester	Mounted Subcomponent	Porcelain Capacity	Yard	No	No	No
	Bushings	Mounted Subcomponent	Porcelain Shift	Yard	No	No	No
	Radiators	Mounted Subcomponent	Not Braced	Yard	No	No	Yes
	Conservator	*Mounted Subcomponent*	Weak Lateral Load Path	Yard	*No*	*No*	Yes
	Sudden Pressure Relay	Mounted Subcomponent	Recoverable if Tripped	Yard	Yes	Yes	Yes
	Intermediate Structure	Tower	Pardee Type Structure-II/I Design	Yard	Yes	No	Yes
	Dead End Structure	Tower	Pardee Type Structure-II/I Design	Yard	Yes	No	Yes
2XU1	Unit Auxiliary Transformer	Power Transformer 22 kV/4.16 kV	Anchorage Capacity	Yard	No	No	Yes
2XU2	Unit Auxiliary Transformer	Power Transformer 22 kV/6.9 kV	Anchorage Capacity	Yard	No	No	Yes
	Radiators	Mounted Subcomponent	Not Braced	Yard	No	No	Yes
	Sudden Pressure Relay	Mounted Subcomponent	Recoverable If Tripped	Yard	Yes	Yes	Yes
IPB	Isophase Bus	Bus 22 kV	Outer Casing Boot	Yard	No	No	Yes
	Isophase Bus Cooling Unit			Yard	Yes	Yes	Yes
2XR1	Reserve Auxiliary Transformer	Power Transformer 220 kV/4.16 kV	Anchorage Capacity	Yard	No	No	Yes
2XR2	Reserve Auxiliary Transformer	Power Transformer 220 kV/4.16 kV	Anchorage Capacity	Yard	No	No	Yes
2XR3	Reserve Auxiliary Transformer	Power Transformer 220 kV/6.9 kV	Anchorage Capacity	Yard	No	No	Yes
	Surge Arresters	Mounted Subcomponent	Porcelain Capacity	Yard	No	No	No
	Bushings	*Mounted Subcomponent*	*Porcelain Shift*	Yard	No	No	*No*
	Radiators	Mounted Subcomponent	Not Braced	Yard	No	No	Yes
	Sudden Pressure Relay	Mounted Subcomponent	Recoverable If Tripped	Yard	Yes	Yes	Yes
	Dead End Structure	Tower	Pardee Type Structure-II/I Design	Yard	Yes	No	No
	Electrical Tunnel			Yard	Yes	Yes	Yes

Electrical Equipment							
Tag	**Item**	**Description**	**Comment**	**Location**	**Anchorage Satisfactory?**	**Free From Known Seismic Vulnerabilities?**	**Free From Seismic Interaction?**
2A01	Bus 2A01	Medium Voltage Switchgear 6.9 kV	Reactor Coolant Pumps	45' Penetration Building	Yes	Yes	Yes
2A02	Bus 2A02	Medium Voltage Switchgear 6.9 kV	Reactor Coolant Pumps	63' Penetration Building	Yes	Yes	Yes
2XR1DSA03	Disconnect Switch	Medium Voltage Switchgear 4.16 kV			Yes	Yes	Yes
2XR1DSA08	Disconnect Switch	Medium Voltage Switchgear 4.16 kV			Yes	Yes	Yes
2XR2DSA07	Disconnect Switch	Medium Voltage Switchgear 4.16 kV			Yes	Yes	Yes
2XR2DSA09	Disconnect Switch	Medium Voltage Switchgear 4.16 kV			Yes	Yes	Yes
2A03	Bus 2A03	Medium Voltage Switchgear 4.16 kV		30' Turbine Building	Yes	Yes	Yes
2A07	Bus 2A07	Medium Voltage Switchgear 4.16 kV		30' Turbine Building	Yes	Yes	Yes
2A08	Bus 2A08	Medium Voltage Switchgear 4.16 kV		85' Control Building	Yes	Yes	Yes
2A09	Bus 2A09	Medium Voltage Switchgear 4.16 kV		85' Control Building	Yes	Yes	Yes
2B01	2B01 Bus	Low Voltage Switchgear 480 V			Yes	Yes	Yes
2B01X	Loadcenter Transformer	Transformer 4.16 kV/480 V			Yes	Yes	Yes
2B02	2B02 Bus	Low Voltage Switchgear 480 V	Pressurizer Heaters		Yes	Yes	Yes
2B02X	Loadcenter Transformer	Transformer 4.16 kV/480 V			Yes	Yes	Yes
2B03	2B03 Bus	Low Voltage Switchgear 480 V		30' Turbine Building	Yes	Yes	Yes
2B03X	Loadcenter Transformer	Transformer 4.16 kV/480 V		30' Turbine Building	Yes	Yes	Yes
2B07	2B07 Bus	Low Voltage Switchgear 480 V		30' Turbine Building	Yes	Yes	Yes
2B07X	Loadcenter Transformer	Transformer 4.16 kV/480 V	SCE Switchyard Relay House	30' Turbine Building	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2B08	2B08 Bus	Low Voltage Switchgear 480 V	Pressurizer Heaters		Yes	Yes	Yes
2B08X	Loadcenter Transformer	Transformer 4.16 kV/480 V			Yes	Yes	Yes
2B09	2B09 Bus	Low Voltage Switchgear 480 V			Yes	Yes	Yes
2B09X	Loadcenter Transformer	Transformer 4.16 kV/480 V			Yes	Yes	Yes
2B10	2B10 Bus	Low Voltage Switchgear 480 V		85' Control Building	Yes	Yes	Yes
2B11	2B11 Bus	Low Voltage Switchgear 480 V		30' Turbine Building	Yes	Yes	Yes
2B11X	Loadcenter Transformer	Transformer 4.16 kV/480 V		30' Turbine Building	Yes	Yes	Yes
2B12	2B12 Bus	Low Voltage Switchgear 480 V		30' Turbine Building	Yes	Yes	Yes
2B12X	Loadcenter Transformer	Transformer 4.16 kV/480 V		30' Turbine Building	Yes	Yes	Yes
2B13	2B13 Bus	Low Voltage Switchgear 480 V		30' Turbine Building	Yes	Yes	Yes
2B13X	Loadcenter Transformer	Transformer 4.16 kV/480 V		30' Turbine Building	Yes	Yes	Yes
2B14	2B14 Bus	Low Voltage Switchgear 480 V		30' Turbine Building	Yes	Yes	Yes
2B14X	Loadcenter Transformer	Transformer 4.16 kV/480 V		30' Turbine Building	Yes	Yes	Yes
2B15	2B15 Bus	Low Voltage Switchgear 480 V		85' Control Building	Yes	Yes	Yes
2B15X	Loadcenter Transformer	Transformer 4.16 kV/480 V		85' Control Building	Yes	Yes	Yes
2B16	2B16 Bus	Low Voltage Switchgear 480 V		85' Control Building	Yes	Yes	Yes
2B16X	Loadcenter Transformer	Transformer 4.16 kV/480 V		85' Control Building	Yes	Yes	Yes
2B18	2B18 Bus	Low Voltage Switchgear 480 V			Yes	Yes	Yes
2B18X	Loadcenter Transformer	Transformer 4.16 kV/480 V			Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2B19	2B19 Bus	Low Voltage Switchgear 480 V		HFMUD	Yes	Yes	Yes
2B24	2B24 Bus	Low Voltage Switchgear 480 V		50' Control Building	Yes	Yes	Yes
2B26	2B26 Bus	Low Voltage Switchgear 480 V		50' Control Building	Yes	Yes	Yes
2/3B58	2/3B58 Bus	Low Voltage Switchgear 480 V		N Industrial Area	Yes	Yes	Yes
2B1611BP	Panel	480 V		56' Control Building	Yes	Yes	Yes
B10X-A	Loadcenter Transformer	Transformer 4.16 kV/480 V			Yes	Yes	Yes
L01X-A	Transformer	Transformer 4.16 kV/208V/120 V	Lighting		Yes	Yes	Yes
L02X-A	Transformer	Transformer 4.16 kV/208V/120 V	Lighting		Yes	Yes	Yes
B10	B10 Bus	Low Voltage Switchgear 480 V	Common Unit Bus		Yes	Yes	Yes
L01	L01 Bus	Low Voltage Switchgear 480 V	Common Unit Lighting Bus		Yes	Yes	Yes
L02	L02 Bus	Low Voltage Switchgear 480 V	Common Unit Lighting Bus		Yes	Yes	Yes
2BX	Motor Control Center	Motor Control Center		50' Control Building	Yes	Yes	Yes
2BA	Motor Control Center	Motor Control Center		45' Penetration Area	Yes	Yes	Yes
2BC	Motor Control Center	Motor Control Center		34' Turbine Building	Yes	Yes	Yes
2BDX	Motor Control Center	Motor Control Center		30' Diesel Generator	Yes	Yes	Yes
2BMX	Motor Control Center	Motor Control Center		30' Turbine Building	Yes	Yes	Yes
2BLX	Motor Control Center	Motor Control Center		30' Turbine Building	Yes	Yes	Yes
2BV	Motor Control Center	Motor Control Center		34' Turbine Building	Yes	Yes	Yes
2BF	Motor Control Center	Motor Control Center		30' Aux FW	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2BB	Motor Control Center	Motor Control Center		7' Turbine Building	Yes	Yes	Yes
2BK	Motor Control Center	Motor Control Center		7' Intake Structure	Yes	Yes	Yes
2BL	Motor Control Center	Motor Control Center		30' Turbine Building	Yes	Yes	Yes
2BDX	Motor Control Center	Motor Control Center		30' Diesel Generator	Yes	Yes	Yes
2BHX	Motor Control Center	Motor Control Center		30' Aux FW	Yes	Yes	Yes
2BW	Motor Control Center	Motor Control Center		7' Turbine Building	Yes	Yes	Yes
2BI	Motor Control Center	Motor Control Center		34' Turbine Building	Yes	Yes	Yes
2BM	Motor Control Center	Motor Control Center		7' Turbine Building	Yes	Yes	Yes
DM	Motor Control Center	Motor Control Center			Yes	Yes	Yes
2BRC	Motor Control Center	Motor Control Center		34' Turbine Building	Yes	Yes	Yes
2BN	Motor Control Center	Motor Control Center		63' Penetration Area	Yes	Yes	Yes
2Q086	Motor Control Center	Motor Control Center			Yes	Yes	Yes
BO	Motor Control Center	Motor Control Center	Common Between Units		Yes	Yes	Yes
BP	Motor Control Center	Motor Control Center	Common Between Units		Yes	Yes	Yes
BG	Motor Control Center	Motor Control Center	Common Between Units		Yes	Yes	Yes
BT	Motor Control Center	Motor Control Center	Common Between Units		Yes	Yes	Yes
BU	Motor Control Center	Motor Control Center	Common Between Units		Yes	Yes	Yes
BQ	Motor Control Center	Motor Control Center	Common Between Units	50' Control Building	Yes	Yes	Yes
BRD	Motor Control Center	Motor Control Center		HFMUD	Yes	Yes	Yes
BRE	Motor Control Center	Motor Control Center		HFMUD	Yes	Yes	Yes
BS	Motor Control Center	Motor Control Center	Common Between Units	50' Control Building	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2T011	Transformer	Transformer 4.16 kV/120 V	UPS		Yes	Yes	Yes
2T014	Transformer	Transformer 4.16 kV/120 V	UPS		Yes	Yes	Yes
2B011	125 V Battery Set		Normal 125 V		Yes	Yes	Yes
2B005	125 V Battery Charger				Yes	Yes	Yes
2D1	125 V Distribution Switchboard			50' Room 310A	Yes	Yes	Yes
2D1P1	125 V Distribution Switchboard			50' Room 310A	Yes	Yes	Yes
2D2	125 V Distribution Switchboard			50' Room 310D	Yes	Yes	Yes
2D2P1	125 V Distribution Switchboard			50' Room 310D	Yes	Yes	Yes
2D3	125 V Distribution Switchboard			50' Room 310B	Yes	Yes	Yes
2D3P1	125 V Distribution Switchboard			50' Room 310B	Yes	Yes	Yes
2D4	125 V Distribution Switchboard			50' Room 310C	Yes	Yes	Yes
2D4P1	125 V Distribution Switchboard			50' Room 310C	Yes	Yes	Yes
2D5	125 V Distribution Switchboard				Yes	Yes	Yes
2Y005	120 V Inverter				Yes	Yes	Yes
2D5P1	125 V Distribution Panel				Yes	Yes	Yes
2D5P2	125 V Distribution Panel				Yes	Yes	Yes
2D5P3	125 V Distribution Panel				Yes	Yes	Yes
2D5P4	125 V Distribution Panel				Yes	Yes	Yes
BA1	125 V Battery Set		Switchyard House		Yes	Yes	Yes
BA2	125 V Battery Set		Switchyard House		Yes	Yes	Yes
BC1	125 V Battery Charger		Switchyard House		Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
BC2	125 V Battery Charger		Switchyard House		Yes	Yes	Yes
DP1	125 V Distribution Switchboard		Switchyard House		Yes	Yes	Yes
DP2	125 V Distribution Panel		Switchyard House		Yes	Yes	Yes
DP3	Distr SWBD		Switchyard House		Yes	Yes	Yes
DP4	Distr Panel		Switchyard House		Yes	Yes	Yes
2B012	250 V Battery Set		Turbine Oil Pressure		Yes	Yes	Yes
2B006A	250 V Battery Charger				Yes	Yes	Yes
2B006	250 V Battery Charger		Standby		Yes	Yes	Yes
2D6	250 V Distribution Switchboard				Yes	Yes	Yes
2B019	250 V Battery Set		Turbine Oil Pressure		Yes	Yes	Yes
2B018E	250 V Battery Charger				Yes	Yes	Yes
2B018W	250 V Battery Charger				Yes	Yes	Yes
2D7	250 V Distribution Switchboard				Yes	Yes	Yes
2B016	250 V Battery Set		UPS		Yes	Yes	Yes
2B015	250 V Battery Charger				Yes	Yes	Yes
2Y012	120 V Inverter				Yes	Yes	Yes
2Y010	120 V Inverter			Turbine Building	Yes	Yes	Yes
2Y011	120 V Inverter			Turbine Building	Yes	Yes	Yes
2B005S	Single Cell Chargers				Yes	Yes	Yes
2B006S	Single Cell Chargers				Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2B015S	Single Cell Chargers				Yes	Yes	Yes
2B018S	Single Cell Chargers				Yes	Yes	Yes
2Q017	Q Panel			45' Penetration Building	Yes	Yes	Yes
2Q018	Q Panel			7' Turbine Building	Yes	Yes	Yes
2Q019	Q Panel			34' Turbine Building	Yes	Yes	Yes
2Q026	Q Panel			30' Turbine Building	Yes	Yes	Yes
2Q027	Q Panel			7' Turbine Building	Yes	Yes	Yes
2Q028	Q Panel			63' Penetration Building	Yes	Yes	Yes
2Q031	Q Panel			50' Control Building	Yes	Yes	Yes
2/3Q032	Q Panel			50' Control Building	Yes	Yes	Yes
2/3Q033	Q Panel			50' Control Building	Yes	Yes	Yes
2/3Q035	Q Panel			50' Control Building	Yes	Yes	Yes
2Q038	Q Panel			34' Turbine Building	Yes	Yes	Yes
2Q039	Q Panel			50' Control Building	Yes	Yes	Yes
2Q040	Q Panel			56' Turbine Building	Yes	Yes	Yes
2Q041	Q Panel			50' Control Building	Yes	Yes	Yes
2Q042	Q Panel			7' Turbine Building	Yes	Yes	Yes
2Q060	Q Panel			30' Control Building	Yes	Yes	Yes
2Q062	Q Panel			50' Control Building	Yes	Yes	Yes
2Q063	Q Panel			50' Control Building	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2Q065	Q Panel			50' Control Building	Yes	Yes	Yes
2Q069	Q Panel			7' Turbine Building	Yes	Yes	Yes
2Q070	Q Panel			7' Turbine Building	Yes	Yes	Yes
2Q071	Q Panel			50' Control Building	Yes	Yes	Yes
2/3Q072	Q Panel			50' Control Building	Yes	Yes	Yes
2Q074	Q Panel			50' Control Building	Yes	Yes	Yes
2Q075	Q Panel			50' Control Building	Yes	Yes	Yes
2/3Q076	Q Panel			70' Control Building	Yes	Yes	Yes
2Q077	Q Panel			30' Turbine Building	Yes	Yes	Yes
2Q078	Q Panel			30' Turbine Building	Yes	Yes	Yes
2Q079	Q Panel			34' Turbine Building	Yes	Yes	Yes
2Q080	Q Panel			34' Turbine Building	Yes	Yes	Yes
2Q083	Q Panel			30' Control Building	Yes	Yes	Yes
2/3Q084	Q Panel			9' Control Building	Yes	Yes	Yes
2/3Q085	Q Panel			HFMUD	Yes	Yes	Yes
2Q0611	Q Panel			7' Turbine Building	Yes	Yes	Yes
2Q0612	Q Panel			50' Control Building	Yes	Yes	Yes
2Q800N				50' Control Building	Yes	Yes	Yes
2Q800S				50' Control Building	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2Q809				9' Control Building	Yes	Yes	Yes
2Q870				70' Control Building	Yes	Yes	Yes
NE Bus	Bus Support Structures			Switchyard	Yes	Yes	Yes
NW Bus	Bus Support Structures			Switchyard	Yes	Yes	Yes
CC (6 each)	Bus Coupling Capacitor	Phase to Ground Coupling Capacitor		Switchyard	Yes	Yes	Yes
"A" Section Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Bus Ground Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
PT (6 each)	Potential Transformer			Switchyard	Yes	Yes	Yes
CCVT (6 each)	Coupling Capacitor Voltage Transformer			Switchyard	Yes	Yes	Yes
CB-4022	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CB-6022	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Line Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV	Downcomer Interaction	Switchyard	Yes	No	No
Ground Disconnect	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
CCVT (4 each)	Coupling Capacitor Voltage Transformer		Downcomer Interaction	Switchyard	No	No	No
Transmission Line Position 2	Dead End Structure		Pardee Type Structure	Switchyard	Yes	No	No

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
CB-4042	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CB-6042	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Line Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV	Downcomer Interaction	Switchyard	Yes	No	No
Ground Disconnect	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
CCVT (3 each)	Coupling Capacitor Voltage Transformer		Downcomer Interaction	Switchyard	No	No	No
CT (3 each)	Current Transformer		Downcomer Interaction	Switchyard	No	No	No
Unit 2 Overhead Line Position 4	Dead End Structures (2 each)		Pardee Type Structure	Switchyard	Yes	No	No
CB-4052	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CB-6052	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Line Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV	Downcomer Interaction	Switchyard	Yes	No	No
Ground Disconnect	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
CCVT (4 each)	Coupling Capacitor Voltage Transformer		Downcomer Interaction	Switchyard	No	No	No
Transmission Line Position 5	Dead End Structure		Pardee Type Structure	Switchyard	Yes	No	No
CB-4062	Generator Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
CB-6062	Generator Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Line Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV	Downcomer Interaction	Switchyard	Yes	No	No
Ground Disconnect	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
CCVT (3 each)	Coupling Capacitor Voltage Transformer		Downcomer Interaction	Switchyard	No	No	No
CT (6 each)	Current Transformer		Downcomer Interaction	Switchyard	No	No	No
Unit 2 Overhead Line Position 6	Dead End Structures (2 each)		Pardee Type Structure	Switchyard	Yes	No	No
CB-4072	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CB-6072	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Line Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV	Downcomer Interaction	Switchyard	Yes	No	No
Ground Disconnect	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
CCVT (3 each)	Coupling Capacitor Voltage Transformer		Downcomer Interaction	Switchyard	No	No	No
Unit 2 Overhead Line position 7	Dead End Structure		Pardee Type Structure	Switchyard	Yes	No	No
CB-4082	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CB-6082	Feed Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
Bus Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
Line Disconnect (2 each)	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV	Downcomer Interaction	Switchyard	Yes	No	No
Ground Disconnect	3 Phase Disconnect Switch	Center Break Disconnect Switch 200 kV		Switchyard	Yes	Yes	Yes
CCVT (3 each)	Coupling Capacitor Voltage Transformer		Downcomer Interaction	Switchyard	No	No	No
Unit 2 Overhead Line Position 8	*Dead End Structure*		*Pardee Type Structure*	*Switchyard*	Yes	*No*	*No*
CB-4112	Cross-Tie Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CB-6112	Cross-Tie Power Circuit Breaker	Dead Tank Gas Circuit Breaker 220 kV	IEEE 693 Qualified	Switchyard	Yes	Yes	Yes
CT (6 each)	Current Transformer			Switchyard	Yes	Yes	Yes
2L-002	Turbine Protection Cubicle			Control Building El.30	Yes	Yes	Yes
2L-014	Unitized Actuator Panel			Control Building El.30	Yes	Yes	Yes
2L-015	Turbine Supervisory Equipment Panel			Control Building El.30	Yes	Yes	Yes
2L-017	Electric Governor Cubicle			Control Building El.30	Yes	Yes	Yes
2L-048	Feedwater Control System Rack 1			Control Building El.30	Yes	Yes	Yes
2L-049	Feedwater Control System Rack 2			Control Building El.30	Yes	Yes	Yes
2L-120	Steam Bypass System Rack			Control Building El.30	Yes	Yes	Yes
2L-4	Gen. Gas Control Cubicle			Turbine Building El. 15	Yes	Yes	Yes
2/3L-104	Air Compressor Panel			Turbine Building El. 15	Yes	Yes	Yes
2L-12	Turbine Protection Cubicle			Turbine Building El. 45	Yes	Yes	Yes
2L-08	Excitation Control Cubicle			Turbine Building El. 45	Yes	Yes	Yes

Electrical Equipment							
Tag	Item	Description	Comment	Location	Anchorage Satisfactory?	Free From Known Seismic Vulnerabilities?	Free From Seismic Interaction?
2L-70	Generator Protective Relay Panel			Control Building El.15	Yes	Yes	Yes
2L-73	Turbine Auxiliary Control Relay Panel			Control Building El.15	Yes	Yes	Yes
Pos. 1-17	Relay Panels			Switchyard Relay House	Yes	Yes	Yes

Explanation:

1. IEEE = Institute of Electrical and Electronics Engineers
2. kV = kilovolts
3. V = volts